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THIS WEEK

● **The cover picture** shows the placing of concrete in the lower part of the outer shell of the first tube section for the Mobile vehicle tunnel. In building that section, concrete was pumped in through openings cut in the side. Others were put in drydock and the concrete was placed from the top.

Photo by Overby Studio, Mobile

● Farley Gannett, whose article "Why So Few Famous Engineers Today?" inspired many a protesting letter last year, has written another article for *News-Record.* This time it's "A Water Supply Is Born," story of an upland water supply for Harrisburg.

● Don't miss Marjory Ellis' tale of home life in the construction town at Bartlett Dam.

● Why is the Delaware Aqueduct a deep pressure tunnel? What factors controlled its location? How will it make New York's supply more flexible? These questions are answered in the second article of a series covering this great metropolitan water supply undertaking.

● Severe rusting and wire breaks in the main cables of General Grant Bridge at Portsmouth, Ohio, forced its owners to take it out of service and undertake a recabling job. How this feat was accomplished is told on page 63.

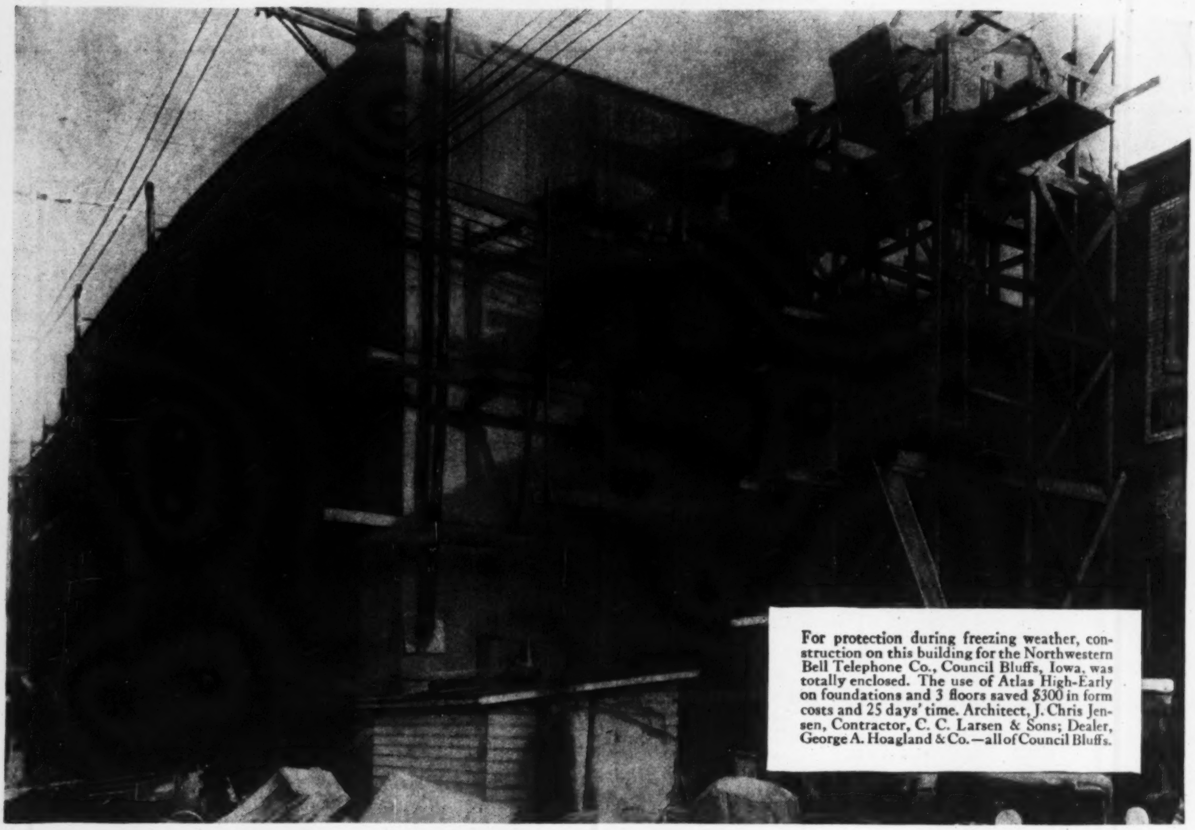
THINGS TO COME

RECENT ISSUES of *ENR* have carried articles on arterial traffic routes in such cities as Pittsburgh, Los Angeles and Cleveland. It's New York's turn in the next issue—an article on the East River Drive, latest link in a system of roadways which eventually will belt Manhattan Island.

LEVEES along the southern shores of Lake Okeechobee in Florida are being enlarged and reinforced with rock dredged from the lake bottom and pumped to place in the levee. That work will be described in the May 9 issue, also the interesting experiments in protecting the levees against attack by hurricane.

ALSO coming in the near future: **The Santee-Cooper Power and Navigation Project.**

SAVED...
25 DAYS AND $300



For protection during freezing weather, construction on this building for the Northwestern Bell Telephone Co., Council Bluffs, Iowa, was totally enclosed. The use of Atlas High-Early on foundations and 3 floors saved $300 in form costs and 25 days' time. Architect, J. Chris Jensen, Contractor, C. C. Larsen & Sons; Dealer, George A. Hoagland & Co.—all of Council Bluffs.

Northwestern Bell Telephone Company Building, Council Bluffs, Iowa, ready for occupancy nearly a month sooner, thanks to Atlas High-Early cement!

CONCRETING of this building could not wait for spring. Work had to be rushed during some of the coldest weather you'll find anywhere. The superstructure was actually concreted in temperatures which were as low as 18° below zero, and never above freezing.

So, the time needed for protection and curing promised to be long and therefore costly. However, the architect found a way to speed construction and keep costs down. He specified Atlas High-Early cement—the cement that gains strength several times faster than normal portland cement. Here's the result:

Concreting of the substructure was started on January 1. The superstructure was completed on March 5. The architect and contractor estimate that the use of Atlas High-Early concrete enabled them to save 25 days' time and, consequently, greatly reduced protection and curing costs. Also, forms were stripped in 36 hours, thus saving one set of forms ... or $300.

Aside from speeding up rush construction, Atlas High-Early cement often pays back its slightly higher cost over and over again by saving days and even weeks of costly building time. Give Atlas High-Early a trial on your next job! Universal Atlas Cement Co. (United States Steel Corporation Subsidiary), Chrysler Building, N. Y. C.

NR-H-12

ATLAS HIGH-EARLY CEMENT

A UNIVERSAL ATLAS PRODUCT

NEWS
ENGINEERING NEWS-RECORD

Volume 124 APRIL 25, 1940 Number 17

Arkansas Seeks Sales Tax On Housing Materials

Payment of the state sales tax for materials used in constructing two Farm Security Administration homestead projects in Arkansas has been demanded by the state revenue department. It is contended that Buford Bracy, Little Rock contractor, who built 72 houses at Plum Bayou Co-operative Association project in Jefferson county and 44 at Clover Bend, Lawrence county, contracted to build with the individual home owners on each project. Attorneys for the contractor maintain that all negotiations have been between him and the federal government.

A total of $2,359 in sales tax is involved.

• • •

Laramie Water Division Confirmed by High Court

By a decision rendered April 22 the U. S. Supreme Court in an opinion by Chief Justice Hughes confirmed its adjudication of 1936 apportioning the waters of the Laramie River between Colorado and Wyoming, which limited Colorado's diversion to 39,750 acre-feet.

The decision was rendered in denying an application by Wyoming to have Colorado adjudged in contempt of court for taking in 1939 more than 12,000 acre-feet in excess of its allowance; the application was denied on the ground that uncertainty existed as to Wyoming's acquiescence in the excessive diversion.

In supporting this action the court stated that the fact of excessive diversion is not controverted, that the apportioned amount refers to total diversion and not to consumptive use, and that Colorado's claim that Wyoming was not deprived is not an admissable defense. Future diversions are to be limited to the allowed 39,750 acre-feet, regardless of whether diversion would cause no injury in Wyoming, but Colorado is left free to allocate the diverted water among its appropriations.

Mid-Continent Engineering Work Engages Am. Soc. C. E. Interest

In addition to local projects and problems spring meeting program in Kansas City included an important symposium on painting of structural steel

With the first day's program devoted to resources—agricultural, industrial, water and mining—of the Mid-Continent area setting the tone, the spring meeting of the American Society of Civil Engineers got under way April 17 with a total registration of 750. Before the week was out eight of the societies divisions had held sessions at which bridge, building, pipeline, water supply, sanitation and waterway projects of the area had been covered. Well attended local section and student chapter conferences were sandwiched between. Outstanding among the general subjects on the program was a symposium on the painting of structural steel. The success of the meeting was due to the activities of a large number of the local members headed by R. N. Bergendoff, president of the Kansas City Section.

Consideration of professional problems occupied the attention of the board of direction prior to the convention. Approval was given to the leadership taken by the society in the formation of the National Conference on Engineering Positions and the appointment of four representatives was authorized. The board received with approval and commendation the report of the study and recommendations of classifications and related salaries of engineers in the Arizona State Highway Department. The investigation was made at the request of the Arizona Section with the full cooperation of the highway department. (See *ENR*, Apr. 11, p. 493.) All recommendations of the committee on professional objectives were approved. Some of these are as follows: That the salary committee investigate the salary situations in the regions of

(*Continued on p.* 36)

Aluminum Co. Expands Pacific Coast Operations

The capacity of the metal producing plant of the Aluminum Company of America at Vancouver, Wash., is to be doubled, according to an announcement of the company made in connection with the signing of an additional contract for Bonneville power. The plant now under construction was designed to produce 30,000,000 lb. of aluminum per year. This is to be increased to 60,000,000 lb. by the addition of two pot room buildings and a six-bay extension to the rectifier building, thus expanding the floor area one third. The cost of this new work is covered in the expansion program announced some months ago (*ENR*, Feb. 8, p. 209).

The expansion is based on the demand of the government's preparedness program, hence the power contract, which is for 32,500 kw. in addition to the earlier contract, is for a five-year period.

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Philadelphia Approves Waterworks Improvements

Citizens of Philadelphia, April 23, at a primary election approved the plan to issue $18,000,000 of bonds for rehabilitating the city's waterworks. The work was recommended by Morris Knowles, Inc., consulting engineers, and by the Better Philadelphia Committee. Voters approved the work by a vote of eight to one as 44 wards out of a total of 51 favored the project.

Details of the proposed improvements are given in *ENR*, Feb. 15, 1940, p. 219 and April 18, 1940, p. 547.

Idaho To Purchase Twin Falls-Jerome Bridge

The Idaho Toll Bridge Commission has voted to buy the inter-county Twin Falls-Jerome Bridge spanning Snake River near Twin Falls on the Sawtooth highway for $482,000. Last June the commission entered into an agreement with the Twin Falls Inter-County Bridge Co. of Seattle, Wash., to buy the span, but legality of the purchase was attacked in the state court. The Idaho State Supreme Court has cleared the way for the purchase by holding the 1939 toll bridge act constitutional.

The federal government is expected to supply 50 per cent of the funds needed for purchase of the span with the state to gain ownership April 30. Tolls amount to about $75,000 annually.

Court Acts Against Sale Of Hetch-Hetchy Power

The U. S. Supreme Court on April 22 ruled that the arrangement by which the city of San Francisco disposes of the power developed in connection with its Hetch-Hetchy water supply system is in direct violation of the act by which Congress in 1913 gave the city the

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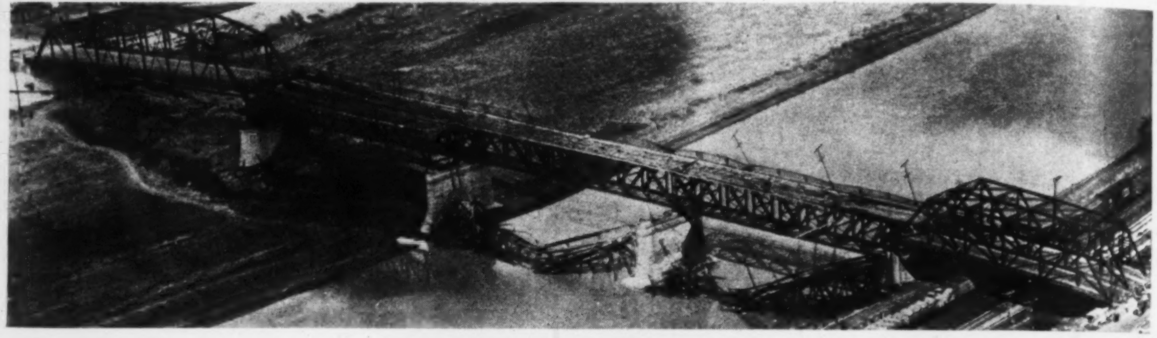
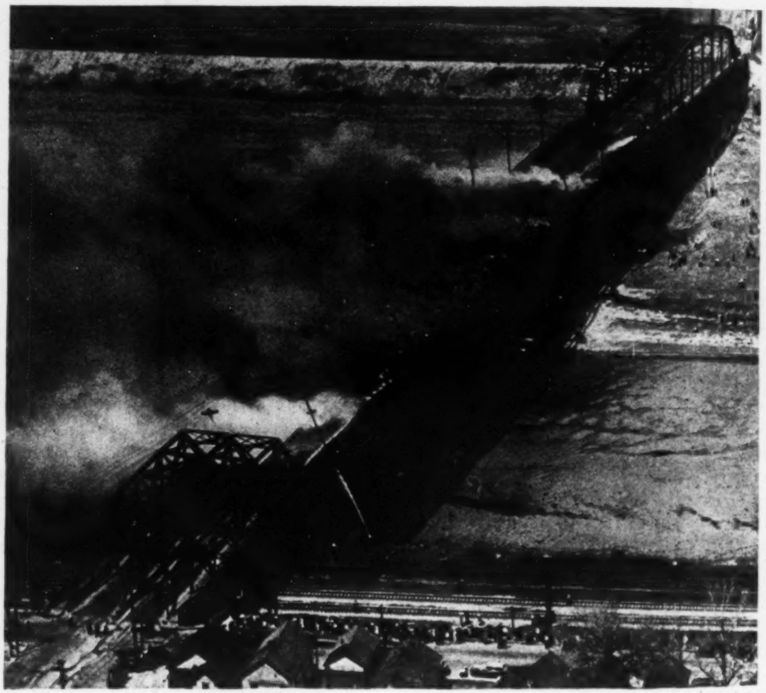
Timber Deck Fire Wrecks Bridge in Kansas City





Sol Studna Airphoto

Fire of undetermined origin, but assumed to have been caused by a locomotive cinder or a dropped cigarette, burned the timber deck from three of the five spans of the 12th St. Bridge across the Kaw River in Kansas City, Kans., on April 16. Before it could be checked the deck trusses supporting the west half of the roadway in two of the spans had collapsed into the river, while the top of the steelwork in the west half of the third span was damaged beyond repair.

Because of a strong wind from the east, the heat was blown away from the east half of these spans, so that the steelwork in this area is apparently little damaged.

The bridge, originally constructed in 1903 and completely rebuilt and doubled in width to 40 ft. in 1924, incident to a raising operation ordered by the Kaw Valley Drainage Board to increase clearance above the waterway, involves a number of different types of steel spans. In the foreground of the upper picture is a 170-ft. through span of three trusses over the A.T.&S.F. railroad tracks. Then follow the three 200-ft. deck spans each of four trusses (actually two separate bridges side by side) while the span on the north is a 270-ft. through truss. In addition to the roadway which carries a double track street car line there are sidewalks at either side. The deck which burned consisted of heavy timber ties laid transversely on the steel stringers and supporting a plank deck. Over this deck was laid an impregnated asphalt building paper on top of which was a creosoted block wearing surface. The building paper is credited with spreading the fire rapidly.

In addition to the monetary loss the fire caused great inconvenience to a large area of the city since the bridge carried two 16-in. water lines and main telephone and electric lines. The bridge also furnishes the only street car connection between the Armourdale and Argentine packing house districts.

Reconstruction of the bridge in 1924 cost Wyandotte County, Kans., the owner, $472,450. Repair will cost much less than this, but none of the loss was covered by insurance. Consideration is being given to a new modern bridge which would cost in the neighborhood of one million dollars.

right to use the Hetch-Hetchy basin for water supply purposes. The Raker Act of 1913 granted the city the right to use public lands for the development of a new water supply on condition that it would sell both the water and the power that could be generated in bringing the water down from the mountains directly to the public so that there would be no private profit. The sponsors of the act contemplated a public power distribution system, but when the power became available the city entered into a contract with the Pacific Gas & Electric Co. to act as its agent in distributing the power and has continued that method of distribution. In 1935 Secretary of the Interior Ickes began action to end that arrangement as being in violation of the Raker Act. The present Supreme Court decision is the result. It sustains an injunction obtained in a lower court where the case now goes for a finding as to when the injunction shall take effect.

In view of the Supreme Court's finding, the city must now either buy or build a distribution system.

North Carolina High Court Upholds Orders Halting Power Project

City of High Point exceeded its authority in obtaining license from the Federal Power Commission, it is held

Without a dissenting vote, the North Carolina state supreme court, April 17, upheld two restraining orders obtained by Yadkin County commissioners and by High Point taxpayers and the Duke Power Co., which halted construction work on a $6,500,000 hydro-electric project being built on the Yadkin River by the city of High Point, N. C. In passing on the case the supreme court ruled that the city of High Point exceeded its authority in obtaining a license from the Federal Power Commission for the project and that, instead, should have applied for a certificate of convenience and necessity from the North Carolina State Utilities Commission. After asserting that the Yadkin River "appeared to be" non-navigable, the court stated, "The Federal Power Commission is not a party to the proceeding and the validity of its license is not an issue. The inquiry goes only to the authority of the city of High Point to agree to abide by its terms and conditions."

Lower court ruling upheld

In the suit brought by the Yadkin County commissioners, the supreme court sided with the lesser court in that High Point had no legal authority to condemn public lands in the county, including roads and part of the county home property, in order to build the hydro-electric plant.

"The power of eminent domain, as generally understood," the supreme court declared, "extends only to the right to condemn private properties for public uses. It is for the general assembly (the North Carolina state legislature) to say whether in the particular case or under certain conditions the power shall be enlarged to embrace public property and property devoted to public use."

Plans for the project called for flooding 14,750 acres in the counties of Yadkin, Davie and Forsyth. High Point is in Guilford County.

City wins one point

That the financing of the project through a PWA loan and grant would not have constituted "a general indebtedness of the city" was the only point in which the supreme court agreed with the city of High Point.

The supreme court in its opinion pointed out that the North Carolina legislature in 1938 "authorized the municipalities of the state to construct, improve and extend revenue-producing undertakings of various kinds, including hydro-electric plans, and to finance them with funds derived from the sale of revenue bonds, payable solely out of the revenues of the undertaking."

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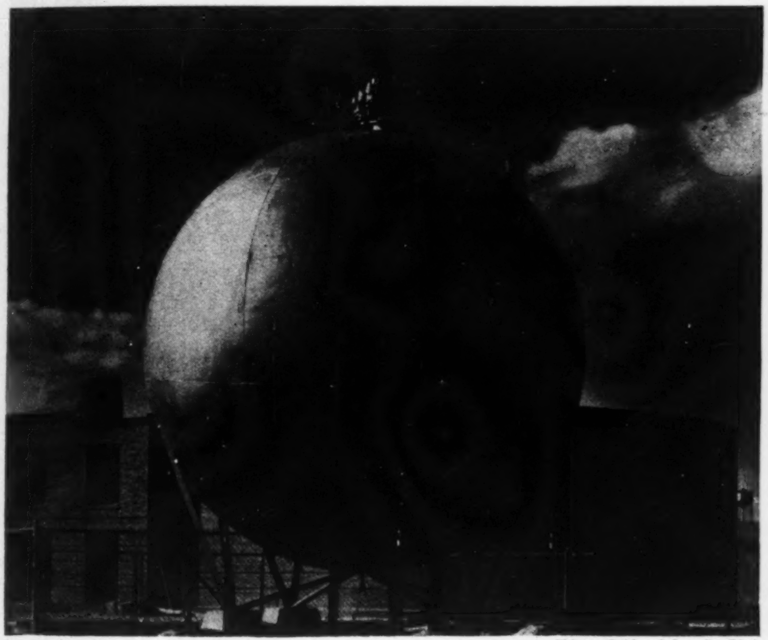


Chicago Bridge & Iron Co. Photo

DOLLARS FROM SEWAGE DISPOSAL

Sludge gas, a byproduct of the digestion process at the New Haven sewage disposal plant, will be stored in this spheroidal tank to supply fuel for heating purposes and to aid in the incineration of sludge. This will eliminate the need for purchasing fuel oil normally required for plant operation.

The New Haven plant, which goes into operation in May, provides sedimentation and sludge digestion treatment; it has a dry weather flow-capacity of 14 mgd. Digested sludge will be dewatered on vacuum filters and then incinerated in a multiple hearth furnace of 48 tons capacity.

The welded spheroidal tank will store 25,000 cu.ft. of sludge gas at a pressure of 30 lb. per sq.in. It was designed and built by the Chicago Bridge and Iron Co.

George Gascoigne and Associates are the engineers on the New Haven plant which is being built under the direction of W. Vincent Barry, director of public works.

Tunnel Plaza Contractors

The Thos. Crimmins Contracting Co. is the contractor for the toll plaza of the Queens-Midtown Tunnel at New York. The company's name was given incorrectly in the listing of contractors of the work shown on p. 11 of our issue of April 18.

WASHINGTON HIGHLIGHTS

Special reports by Paul Wooton

MAKING its second offering of long-term housing authority bonds, USHA is planning to sell only about 18 per cent of them to the public, only a little over the statutory minimum of 10 per cent. This is in spite of the fact that on the first offering as much as 25 per cent was sold to the public by the Utica authority. Reason is that several amendments are being worked up in committee for insertion in the pending housing bill which it is believed will make the bonds more attractive. If these plans go through, the outstanding bonds will probably be refunded, and since a 3 per cent premium must be paid when the bonds are called it is not desired to get too many of them out.

CANALIZATION of the San Juan River in Nicaragua (*ENR* Nov. 16, 1939, p. 657) to provide a shallow-draft connection between the Atlantic and Lake Nicaragua in the interior has been forwarded by signature of a treaty between Nicaragua and Costa Rica. Through part of its length the San Juan forms the boundary between the two countries. Under the treaty, which has still to be ratified by the respective legislatures, Costa Rica grants easements for dam abutments on its shore and the right to flood Costa Rican territory, though Nicaragua must pay damages to private landowners. In return, Costa Rica receives navigation rights on the entire length of the proposed canal and free port rights at the proposed Greystown terminus in Nicaraguan territory. Similar rights are granted on a barge connection from Lake Nicaragua to the Pacific if this should ever be built.

RFC has agreed to loan the Republic of Panama $2,000,000 for completion of a road across the Isthmus of Panama. The section from Madden Dam to Colon, about 22 miles, remains to be built.

ANOTHER ATTEMPT is being made in Congress to remove from bridge-owners the entire cost of altering or replacing existing bridges found to interfere with navigation. A bill introduced into the House by Rep. Sam Hobbs, Alabama Democrat, provides that when a bridge is changed in the interests of naviga-

Caterpillar Tractor Photo

WORLD'S LARGEST DRY-FILL DAM NEARS COMPLETION IN CALIFORNIA

WORK is well advanced on Hansen Dam, World's largest dry-fill dam being built in California just below confluence of the Big and Little Tunjunga canyons. When complete the dam, 120 ft. high and 9,500 ft. long, will contain 14,700,000 cu.yd. of material. It will be exceeded in size by only four other earth dams, all of them hydraulic fills—Fort Peck, Kingsley, Gatun and Sardis dams.

The spillway, a concrete ogee section with an effective length of 284 ft. and crest 70 ft. above sill elevation of the outlet conduits, may be seen in the middle foreground. It will have a capacity of 101,000 cfs.

Hansen Dam is under the supervision of the Los Angeles office of the U. S. Engineer Department, Lt.-Col. Edwin C. Kelton, district engineer; Capt. N. A. Matthias, chief, engineering division; Capt. Lyle Rosenberg, chief, construction division; and Wm. J. Leen, construction engineer; George J. F. Carey, area engineer, first field area; A. H. Steiner, resident engineer at the dam. The general contract is held by the Guy F. Atkinson Co.; Geo. H. Atkinson, job manager; A. Earle Holt, general superintendent; D. E. Root, chief engineer; John A. Kier, assistant superintendent, and E. M. Jennett, assistant manager.

tion, the United States bear all the costs except those chargeable to benefits to land traffic. At present the bridge owner bears the entire cost.

A similar bill was passed by Congress last year but was vetoed by the President on the recommendation of the War Department. The present bill retains the major features of the previous measure but would include maintenance savings in the items to be charged to the bridge owner and would allocate a share of the cost to other interests, such as public bodies, which will be benefited by alteration of the bridge.

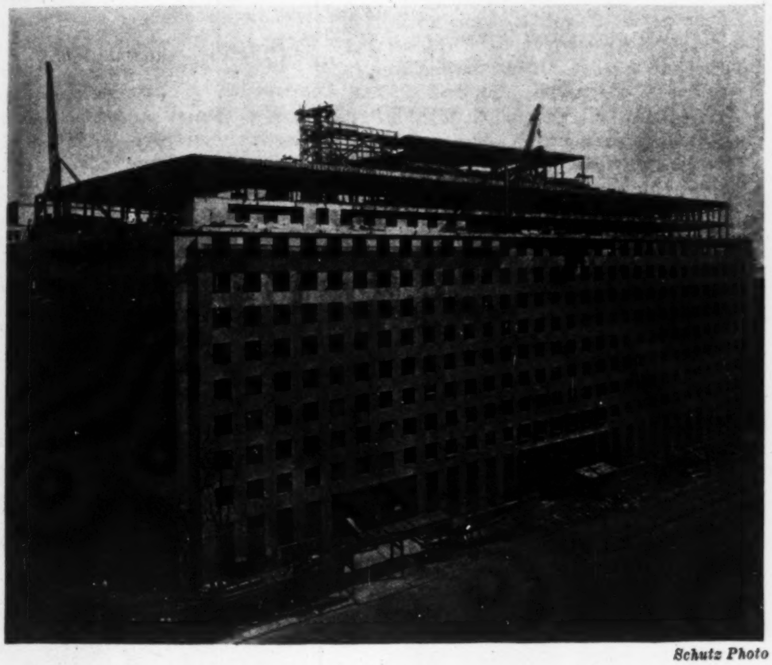
The Corps of Engineers is believed not to have retreated from its opposition to any change in the present procedure, but proponents of Hobbs' bill appear confident it will not meet the fate of last years proposal.

Some years ago a special committee of the American Society of Civil Engineers studied this subject and made recommendations in line with present legislation.

Robert W. Waddell Dies; Engineer of Kansas City

Robert William Waddell, 80, city engineer of Kansas City, Mo., since 1918, died in that city April 19. Waddell, a brother of the late J. A. L. Waddell, famed bridge engineer, was born in Port Hope, Ont., Canada, Oct. 31, 1859. He received his education at McGill College, Montreal, graduating in 1881. Following graduation he was appointed assistant engineer of waterworks at Omaha, Neb., leaving after several months to go to Denver to do general engineering work.

In 1900 Waddell was appointed city engineer of Kansas City, to resign in 1903 to return to private practice. In 1918 he again entered city service as assistant engineer, three months later becoming chief engineer. Except for a brief period in 1925 and 1926, he has held that position continuously since. He was a former president of the Kansas City Chapter of the American Society of Civil Engineers.



Schutz Photo

WASHINGTON'S LARGEST PRIVATELY-OWNED OFFICE BUILDING

Lafayette Building, largest privately owned office building in Washington, D. C., is scheduled for completion in August. A 12-story and 2-basement structure with 350,000 sq.ft. of rentable space, its construction will cost about $4,000,000 and land will bring the total cost to about $6,000,000. The structure is of steel frame type with tile arch floors; though mostly founded on spread footings, there are 168 concrete piles in the foundation.

Unusual features are provision for inside storage of 130 automobiles and an air-conditioning system separately adjustable from each room. A. R. Clas Associates of Washington and Holabird & Root of Chicago are architects, and A. J. Scullen is structural engineer.

Thompson-Starrett, New York City, represented on the job by Rodney J. Smith, holds the construction contract on a cost-plus basis. Owner is the Lafayette Building Corp., Washington, D. C.

Senate Votes Funds For Panama Locks

War Department civil functions bill provides $15,000,000 for start of construction

The Senate last week passed and sent to conference a War Department civil functions appropriation bill restoring all the cuts below the budget and adding to budget figures in certain instances. Largest increase over the House bill is provision of $15,000,000 to start construction of the third set of locks at Panama; the House turned down the budget request on this but it was restored in the Senate. Authorization to enter into contracts totalling $99,000,000 on this project is also granted. Both houses provide $19,000,000 for works protecting present locks against sabotage or attack.

Power and flood control

The Senate went over the budget in appropriating $3,400,000 for installation of power facilities at Bonneville Dam; the House had accepted the budget figure of $800,000. Bonneville power is being sold more rapidly than was originally anticipated, and the authority has already contracted to sell more power than it can now generate. Both chambers appropriated the budgeted $2,000,000 for power installations at Fort Peck Dam.

For flood control, both versions provide $70,000,000 for general flood control, $30,000,000 for the Mississippi River, and $800,000 for emergency work on Mississippi tributaries. The Senate, however, doubled the House, and budget, figure for Sacramento River flood control, providing $1,242,000 and also inserted an unbudgeted item of $249,000 for the East Hartford, Conn., flood control project.

$25,000,000 for river work

Both Senate and House appropriate $25,000,000 for new river and harbor construction; for river and harbor maintenance the Senate went back to the budget figure of $43,000,000 which the House had cut by a million and a quarter.

The Senate inserted $1,210,000 for topographic mapping of strategic areas. The budget had included $1,970,000 for this purpose in the Interior Department bill, but it was dropped out of that measure as fitting more appropriately into the War Department bill.

Technical, supervisory, and white-collar employes of the Panama Canal are required by the bill to be citizens either of the United States or of Panama and must be paid 25 per cent more than employees in the United States.

Civil Engineers Meet

(Continued from p. 31)

low compensation and of state highway departments after a state-by-state comparison has been made. That a renewed effort be made to bring geographical records up to date. The committee called attention to the fact that the 16,000 members received an annual compensation of $60,000,000 and that more than one-half are governmentally employed with salaries below the average, hence need the society's help first.

Convention meeting places in 1941 were chosen as follows: Spring, Baltimore; summer, San Diego; fall, Chicago. This year's summer meeting is in Denver, July 24-26, and the fall meeting in Cincinnati, Oct. 16-18.

Construction's "common cold"

One of the most important problems facing the engineer today is the painting of structural steel. An old problem, it has recently assumed new importance because of developments in paint and application technique that hold some promise of a solution. The outstanding feature of the program was a symposium on conditioning steel for painting and in introducing the discussion E. R. Needles, consulting engineer, New York, likened the failure of the engineering profession to prevent steel corrosion with the failure of the medical profession to prevent the common cold. Corrosion, construction's common cold, is constantly being studied and discussed but results to date have not been very heartening. After discussing the chaotic condition of present practices Needles listed three essentials that appeal to him: (1) Clean the steel thoroughly by sandblasting to blue (not bright) steel or flame cleaning; (2) use synthetic resin vehicles instead of linseed oil; and (3) place responsibility for results squarely on some definite individual's shoulders.

There was not complete agreement with these recommendations, as Needles predicted there would not be, but they were surprisingly close to a composite summary of the papers by A. B. Davis, Virginia Bridge Co.; F. H. Dill, American Bridge Co.; F. C. Hutchison, Linde Air Products Co.; R. G. Cone, engineer, Golden Gate Bridge; C. F. Rassweiler, du Pont; Jonathan Jones, Bethlehem Steel Corp.; and J. G. Magrath, Air Reduction Sales Co.

The composite summary would include the following points. Cleaning of all loose mill scale before the shop paint or primer coat is applied is absolutely essential. Hand cleaning methods are no good and machine brushing is little better. Sandblasting is satisfactory but has the disadvantage of a siliceous hazard; blowing of sand onto nearby painting operations; leaving sand in crevices; and requiring work to be done indoors or in good weather. Cleaning with the oxy-acetylene flame, causing scale to expand and break away, and at the same time heating the steel and drawing off the moisture is satisfactory and offers much promise.

Flame cleaning of steel

Flame cleaning torches have been developed after a long investigation that meet every requirement. Using a neutral flame, and thus causing no cutting of the steel, these tools can be operated at from 10 to 30 ft. per min. A 6-in. width of head weighing about 6 lb. is most widely satisfactory size, but button head tools are necessary for corners and rivet bends. Flame cleaning must be followed by wire brushing and then dust removed by a dry paint brush. Compressed air cleaning is no good after flame application because it chills the steel causing moisture condensation. Flame cleaning and dehydration do not remove grease; this must be washed off with a solvent.

In his paper, Rassweiler gave an illuminating discussion of the corrosion process and methods of combatting it. Corrosion is a chemical process depending upon electrolytic action. It therefore requires moisture which serves as the electrolyte in tiny cells formed between points of different potential. Through the action of these cells oxygen and water combine to form hydrated iron oxide which is rust. The need therefore is to reduce the differences in potentials and/or to reduce the conductivity of the water. Salt water increases rusting because it increases the conductivity of water.

Paints, said Rassweiler, are all permeable but vehicles can be made that are nearly resistant to water. Synthetic vehicles are much better in this respect than the oil type. The purpose of the pigment is to inhibit rust and not to exclude moisture. Red lead is one of the best.

Principal disagreement with the theory of unusually careful cleaning of steel came from Jonathan Jones, who favored reasonable removal of mill scale prior to painting followed by patch painting in a year or two after the remainder of the loose scale had peeled off in service. He characterized this as low cost cleaning, 50c. per ton as against $4 for sandblasting or flame cleaning. Jones emphasized the need for an authoritative unbiased specification for the cleaning and painting of structural steel.

Three papers in the construction division session and four in the highway session covered a wide range of interests. The important part that the Mid-West played in early bridge building—witness Ead's Mississippi River crossing at St. Louis and Chanute's Hannibal Bridge over the Missouri at Kansas City—was recalled in a paper by H. S. Tullock, president, Missouri Valley Bridge & Iron Co. When full account is taken of the tools and machinery available today, Tullock said, our huge modern structures represent no greater accomplishment than did these early bridges. A second paper by S. J. Callahan, Kansas City, Mo., public works department, described the municipal auditorium and theatre while a third by A. H. Riney, vice-president, and Stanley Learned, chief engineer, Phillips Petroleum Co., covered gasoline pipeline design and construction.

Gasoline lines are the baby of the industry, the authors said, the total mileage being 6,800 compared to 183,000 for natural gas and 128,000 for crude oil. In the days when gasoline formed only a small part of the distillate, it was more sensible to pipe the crude but as the gasoline yield has increased it becomes more economical to place refineries at the producing end and pipe the gasoline.

Pipeline construction

Construction of gasoline lines has developed a special procedure to keep the pipe absolutely clean inside, the fabricator sealing the ends of each length with a metal disk, which is removed just before the joint is welded, and the owner using special cleaning methods during the line testing period. On one of the Phillips' lines this involved mixing caustic soda with the test water to raise its pH value to about 10. This water so cleaned the pipe that the coefficient C in the Hagen and Williams formula was raised to 150; usual water supply lines assume a coefficient of only 100 it will be recalled.

The highway papers were concerned with the current problems of Missouri, Kansas and Colorado and were presented by the chief engineers of the respective highway departments, C. W. Brown, R. B. Wills and Charles D. Vail. F. V. Reagel of Missouri also described the extensive soil studies that he has supervised.

Waterways

Five speakers covered waterway subjects relating to the Mississippi and Missouri rivers. D. R. Neff, senior engineer, U. S. Engineers, Kansas City, Mo., outlined the development and maintenance of a navigable channel in the Missouri. Following the lead of the engineers on the Mississippi, cutoffs are now being made on the upper stream. Nine have been made above Kansas City and several below. In the new technique draglines and dredges are employed. Also asphalt revetment is being used, some 20,000 ft. having been laid in the Omaha District. Neff indicated that 92 per cent of the mileage of the Missouri in the project has a depth of 6 ft. and width of 200 ft.; 82 per cent has 9 ft. and 300 ft., respectively.

Effect of cutoffs

George R. Clemens, senior engineer, Mississippi River Commission, Vicksburg, Miss., presented data on the effects on navigation from recent cutoffs and channel improvements on the Mississippi begun in 1932. An exhaustive study epitomized in charts has been made of "before and after" records of actual operation of the five principal towing agencies. That the whole navigation in the reach from Arkansas River to Old River has been improved was Clemens' conclusion. Upstream running time through the cutoff section has been materially reduced for low and medium stages. At high stages for heavy tows there has been some increase in running time. Downstream trips generally have been improved at all stages. The net result has been a net decrease in running time when consideration is given to the size of the tow and the stage of the river.

Development of a soft water for Wichita, Kan., from an underground "reservoir" trapped in an ancient geologic water course is well on the way toward completion. R. E. Lawrence of Black & Veatch, consulting engineers, Kansas City, outlined the peculiar geologic formation discovered many years ago but only considered economically possible of development with PWA aid. Unlike most water supply developments which are undertaken to relieve a shortage Wichita has plenty of well water, hard but cheaply produced, and is going 35 mi. to obtain a softer water. The chemical content of the existing supply from shallow wells tapping the underflow of the Arkansas has a total hardness varying from 373 to 475 ppm and chlorides of from 473 to 630. The hardness of the new supply is less than 180 ppm and chloride content 35 ppm.

Future water problems

Ernest Boyce, engineer and director, Kansas State Board of Health, described developments and future problems in water supply and sanitary sewage in the Mid-Continent area. He emphasized the need for the collection of long-period hydrological observations, as improved transportation facilities have often relocated municipalities in localities with inadequate surface or groundwater supplies. Pollution of the Missouri continues despite an historic report of 1912 calling for its restriction. "The public accepts," Boyce said, "with a confidence that is both complimentary and disturbing, the effectiveness of modern water purification processes in affording reasonable protection against water-borne disease." Drought years emphasize the need for storage either above or below ground. Especial attention was called to underground migration of mineralized water through imperfectly cased or abandoned oil wells or through seepages from the surface of brines produced with oil.

In discussion W. W. Horner, consulting engineer, St. Louis, indicated the possible need for large-scale sewage disposal plants for Kansas City and St. Louis.

In the hydraulics division two papers of theoretical nature were developed. Samuel Shulitz, associate engineer, U. S. Engineers Office, Louisville, Ky., presented a mathematical treatment of turbulence in which he emphasized the need for experiments to determine the exchange coefficient. In discussion A. A. Kalinske, assistant professor, Iowa Institute of Hydraulic Research, Iowa City, Ia., outlined a photographic method he is using to measure the exchange coefficient directly.

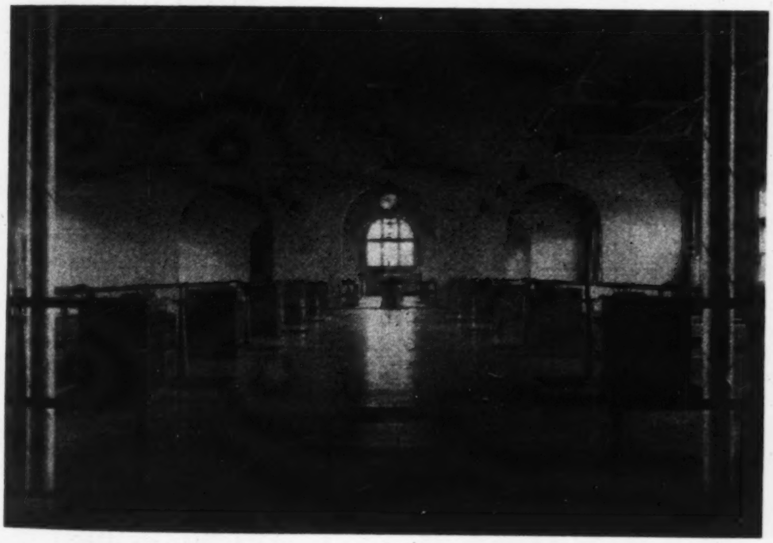
W. W. Horner, consulting engineer, St. Louis, Mo., indicated in his paper a method of constructing surface runoff hydrographs in drainage problems by using the rate of infiltration into the ground and the precipitation.

The surveying and mapping program was featured by a paper on reconnaissance surveys by L. B. Roberts, New York, whose wide experience on work in Asia's Gobi desert, in Africa, and in South America has provided him with a wealth of information on the short cuts that make such surveys efficient. "Never attempt to standardize any particular method of reconnaissance" is Roberts' plea because this is one field where the engineer's ingenuity should have full play. William Bowie, recently retired from the U. S. Coast and Geodetic Survey, outlined the mapping program of the United States.

City planning

In the joint program of the city planning and engineering economics divisions, Lewis E. Thomas, professor of geography, Washington University, St. Louis, Mo., covered the economics considerations involved in the planning of cities from a geographer's viewpoint, viz., site, location and life cycle. A study of the stage of the cycle, youth, maturity or old age indicates where to place plan emphasis.

F. Dodd McHugh, director of research, New York City Planning Commission, compared costs to the city for public services in new and in old residential areas.



EVANSVILLE WATERWORKS REVAMPED FOLLOWING 1937 FLOODS

OPERATING GALLERY of the Evansville, Ind., filter building where six new 1.5-mgd filters have been installed as part of the rehabilitation program of the waterworks plant following a 4-day shutdown when the plant was flooded in 1937. A new laboratory, an over-and-under sedimentation basin, a new flocculator, renewed chemical feed equipment of the vibrating gravimetric type have all been installed along with a new 2-mgd pump unit, 400-kw turbo generator, raised levees and cleaned intakes.

L. A. Geupel is superintendent of the water department.

OBITUARY

Joseph C. Gilbert, senior civil engineer with the TVA in the project, planning division on the Watts Bar project, died early this month in Punta Gorda, Fla. Gilbert, a graduate of Drexel Institute in 1922 with a structural engineering degree, from 1924 to 1930 worked with the U.G.I. Construction Co., Philadelphia, on construction. In 1930 he joined C. H. Locher, consulting engineer, to do hydraulic work. From 1930 to 1933 he was employed by United Engineers & Constructors, Inc., Philadelphia, Pa., leaving there in 1933 to become field engineer for the TVA on Wheeler Dam.

Horace L. Seymour, 57, engineer and town planning consultant at Ottawa, Ont., died in that city April 21. From 1926 to 1929 Seymour was resident engineer of the Vancouver, B. C., town planning commission. He formulated the town planning act of the three provinces of Alberta, New Brunswick and Nova Scotia.

John W. Ballew, 70, former city manager of Hickory, N. C., died in that city April 16. In 1913 Ballew was named superintendent of the Hickory municipal waterworks department, later becoming connected with the city street department. In 1916 he was elected city manager of Hickory and served until March, 1920. In 1922 he was again named city manager and served until 1925.

Herbert E. Andrews, assistant engineer with the Massachusetts Department of Public Works, died April 15. Andrews had been associated with the department since 1912, for the last 15 years having been assistant engineer at the Worcester office.

Henry P. Drake, assistant chief engineer of the Pennsylvania Department of Health, died in Harrisburg April 17. Following his graduation from Massachusetts Institute of Technology in 1904, Drake worked with the Massachusetts Department of Health, the J. L. Mott Iron Works, the Pittsburg Flood Commission, the Hydro-Electric Co. of West Virginia, and the Water Supply Commission of Pennsylvania. He joined the engineering staff of the Pennsylvania Department of Health in 1915.

Daniel F. Cummings, 48, president of the Matthew J. Cummings Construction Co., Boston, died April 17 on board the S.S. Chiriqui, while returning from a South American vacation.

Wilbur C. Schwier, 44, civil engineer of Indianapolis, died in that city April 16. For 15 years Schwier was employed by the Indianapolis Union Ry. leaving in 1932 to join the Public Service Co. of Indiana.

Frank G. Flood, head of the state highway testing department at Portland, Conn., died in that city April 18. Flood studied at Wesleyan University and Yale University. He had been with the Connecticut State Highway Department for 28 years.

Calvin A. Lichty, 74, for many years secretary of the American Railway Bridge and Building Association and the Roadmasters Association of America, died in Chicago April 18. He entered the engineering department of the Chicago & Northwestern Ry. in 1892, and later became inspector of materials.

John R. Higgins, former superintendent of sewers in Queens Borough, New York, died in Roselle, N. J., April 21 at the age of 65. Following his education at Pratt Institute, Brooklyn, Higgins organized the firm of Tulle & Higgins. He retired several years ago.

CONTRACTS AND CAPITAL

Private engineering construction awards for the week top the corresponding 1939 week by 25 per cent, and are 1 per cent above a week ago. This is the fourth successive week that private awards have exceeded their respective 1939 values.

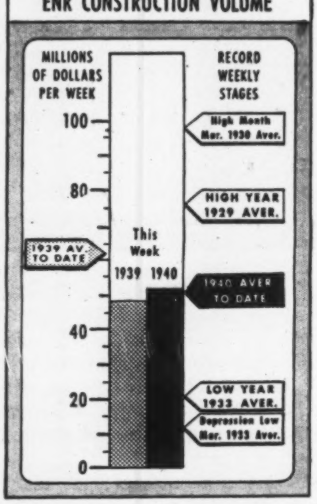
The week's total, $51,753,000, is 7 per cent above the volume for a year ago as a result of the private gain, but is 3 per cent below the preceding week. Public construction is 1 per cent lower than last year, and 5 per cent under last week.

The 1940 construction volume, $854,557,000, is 18 per cent below the level for the 17-week period last year. Private construction, however, is 12 per cent higher than in the 1939 period.

In the classified construction groups, sewerage, bridges, commercial building and large-scale private housing, streets and roads, and unclassified construction top their respective totals of a week ago; and waterworks, sewerage, industrial and commercial buildings, and streets and roads are higher than in the 1939 week.

New capital for construction purposes for the week totals $17,667,000, a decrease of 74 per cent from the 1939 week when the total was boosted by a federal appropriation for WPA construction. The week's financing is made up of $11,839,000 in corporate security issues, and $5,828,000 in state and municipal bonds.

New construction financing for the year to date, $365,300,000 is 45 per cent below the volume reported for the corresponding 17-week period last year.



CONTRACTS

(Thousands of dollars)

	Week Ending Apr. 27 1939	Week Ending Apr. 18 1940	Week Ending Apr. 25 1940
Federal	$3,512	$4,483	$3,331
State & Municipal	29,623	29,983	29,455
Total public....	$33,135	$34,466	$32,786
Total private...	15,162	18,870	18,967
TOTALS	$48,297	$53,336	$51,753
Cumulative			
1940 ......(17 weeks)...			$854,557
1939 ......(17 weeks)...			$1,041,837

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial building, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

	Cumulative 1939 17 Wks.	Cumulative 1940 17 Wks.
NON-FEDERAL ...	$357,457	$365,300
Corp. securities..	68,184	66,211
State & Mun.....	209,938	225,026
R.E.A. loans.....	22,211	......
U.S.H.A. loans...	56,890	73,551
R.F.C. loans.....	234	512
FEDERAL	$311,200	$......
TOTAL CAPITAL..	$668,657	$365,300

FHA MORTGAGES

	Week Ending Apr. 22 1939	Week Ending Apr. 13 1940	Week Ending Apr. 20 1940
Selected for appraisal	$25,576	$29,978	$28,202*
Cumulative			
1940 ......(16 weeks)....			$355,161*
1939 ......(16 weeks)....			$363,257

* Subject to revision.

ENR INDEX NUMBERS

Index Base = 100		1913	1926
Construction Cost	Apr. '40..	238.26	114.53
Building Cost	Apr. '40..	201.44	108.89
Volume	Mar. '40..	162	71

COMMENT AND DISCUSSION

Readers' opinions on matters that concern the engineer

Navigation and Power

Sir: In "A Preview of Santee-Cooper" (*ENR*, March 14, p. 375), Mr. Boughton implies that construction of a navigation lock will "take some of the cost off of power."

The reverse is the case. The entire project, lock and all, is built under a PWA loan and grant with no source of revenue except power. The power cost will therefore be increased in the proportion that the lock increases the total cost of the project.

I see no way in which this could be changed unless at some later date Congress were to refund to the South Carolina Public Service Authority its investment in the lock or assume debt service on same, and also assume the cost of its operation.

L. F. Harza
Charleston, S. C.

The possibility that Mr. Harza outlines in his last paragraph was what inspired the comment in question. The authority, in asking Congress to reimburse it for expenditures chargeable to navigation, would be following a precedent established at Bonneville and on the Tennessee River.—Editors.

Professional Engineers

Sir: In the issue of January 4, 1940, Engineer I. E. Morris has a letter entitled "Publicity for Engineers."

The New York State Society of Professional Engineers, which is affiliated with the National Society, has recognized the necessity of taking the engineer out of the "modest violet" class in a practical way. Various chapters of the society have appointed publicity committees with a chairman for each chapter. Lists of consulting engineer members have been made and tabulated for the specialties in which these consultants are engaged. These lists have been filed in the central offices of the chapters for use by the public. Advertisements have been placed in the New York Law Journal advising lawyers that consultants are available for their technical engineering problems.

The chairmen of the publicity committees endeavor to have published in the newspapers notices of important meetings and of interesting persons who address these meetings. Lists of consultants have been furnished by some chapters to the defense forces of the United States for use in emergency.

Meetings have been arranged with committees of other professional bodies such as accountants and publication has been made in their journal emphasizing the value of the engineers' services to the accountants, and informing them of the available consulting engineers' lists.

Sound publicity as to the merit and value of the engineer to the community will follow from efforts as outlined. The engineer should become accustomed to seeking publicity. In each community instances occur where an engineer performs signal service or where the employment of an engineer might have avoided a disaster. On such occasions a professional engineer will do his colleagues a publicity favor if such items were brought to public notice either by letter in the newspapers or as news.

If the individual engineers can become interested in their own welfare, they will become articulate, and publicity and its benefits will follow. The public is always news-hungry. Let the engineer provide engineering news.

Jacob Mark
Professional Engineer
Brooklyn

Praise for the Joint Meeting

Sir: You are to be commended for presenting to a wide reading public the fine work of the Joint Meeting in Essex and Union counties, New Jersey, reported by its able and public-spirited chairman, Peter A. Smith (*ENR*, March 14, 1940).

As Acting Chief Engineer of the PWA in New Jersey, the writer had the opportunity, in the activities of completing the treatment works, to observe the Joint Meeting at close range. A cooperative venture of twelve municipalities in sewage treatment, the Joint Meeting is an outstanding example of the principle of "service area" practice. If we are to obtain and maintain clean streams in the United States at a reasonable cost to the taxpayer it is imperative that the problem of pollution abatement be approached cooperatively. Such cooperation need not involve huge unwieldy enterprises; rather it should be a practical integration by joint action into logical service areas determined solely on the basis of efficiency and economy. For each municipality to construct its own treatment plant limited strictly to its political boundaries is to disregard the fundamental nature of the problem and is neither efficient nor economical as a solution of the problem.

Too frequently we are so concerned with the initial construction of sewage treatment facilities that we neglect to give consideration to continuous and efficient operation of the works. Size of plant is an important factor in efficiency of operation—very small works cannot afford the services of expert supervision and on the other hand, size beyond naturally integrated service areas runs the danger of topheaviness and red tape.

No procedure can be any better than the intelligence and integrity of the public officials behind it. Even more than a demonstration of the "service area" principle, the Joint Meeting under able leadership and with a fine staff has set a pace in public administration that many private businesses would find difficult to equal.

C. J. Velz
Head of the Department and
Professor of Sanitary Engineering,
School of Engineering
Manhattan College, New York

Credit Where Credit Is Due

In the news article in the March 28 issue, p. 428, describing the new plant of the Austin-Western Co. at Aurora, Ill., it should have been noted that the James Stewart Corp., Chicago, was the builder.

In the article on the Grand Rapids, Mich., water supply, the fact that the Moretrench Corp., Rockaway, N. J., installed the wellpoint installation on the Fry & Kain contract covering the pipeline in the city and the river crossing was inadvertently omitted by the writers.

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April 25, 1940

Time was when bridge deck fires would not have been considered spectacular news. Two or three decades ago they were as common as tenement-house fires are today. Current scarcity therefore is the justification for the story in our news pages of the burning of a timber deck on a bridge in Kansas City last week. There is also another reason for noting this fire, and that is to get some reflective satisfaction out of the progress made in rendering bridges fireproof. Since the Hanrahan Bridge fire this progress has been rapid. Starting with the concrete floor, which in its first applications was too heavy, progress produced the concrete-filled steel grid, the open-mesh steel grid and the steel plate and steel channel floor, and even included the laminated timber floor, an improvement over its ancestors which may or may not be fireproof but whose record so far is unblemished. There is no new lesson in the Kansas City bridge fire, unless it is that old timber floors should be replaced. But we already know that lesson. It is entirely as a rare event that the Kansas City fire has a claim to our interest and brings to mind the advance that has been made.

What Is Professional Work?

The Wage Hour Administration in Washington is now engaged in trying to define and delimit professional workers, who are exempted from the Wage-Hour Act by the terms of the act itself. Rulings of the administrator have left the door open for a wide variety of interpretations, any one of which could have a disorganizing effect on an engineering staff whose work might or might not be classified as professional, depending upon the whim of the local wage-hour administrator. The uncertainty also gave union organizers an opportunity to harass engineering firms whose organizations have not been receptive to their approach. This condition should not have lasted as many months as it has, and it calls for early and clean-cut decision. Few will want the law to be so interpreted as to permit the exploitation of men through long hours and low pay under protection of a professional exemption. On the other hand, the definition of professional work should not be so finely drawn as to have the effect of deadening the ambition of men who prefer the freedom of being classed as professional men.

No Half-Way Measures

Rising waters in many rivers serve to emphasize the fact that half measures may be worse than no protection in flood control. When flood-protection works for a city are begun they must be carried through to completion if damage sometimes worse than that of former years is to be avoided. At Wilkes-Barre, Pa., a few weeks ago a wide area that should have been protected by an enlarged levee system was flooded through an improperly protected opening left for a railroad spur. Similarly other cities that now are threatened may experience destruction arising from uncompleted protective works. The damage done by an overtopped levee generally is worse than that caused by the slow rise of waters that occurred before any levee was built. If there is serious damage in current floods to towns and cities that have begun work for flood protection, it must be recognized not as evidence of the fruitlessness of what has been done but as a clear showing that flood-control works must be pushed to completion if safety is to be assured.

The Common Cold of Construction

If the symposium on painting of structural steel, which was the outstanding feature of the A.S.C.E. convention program in Kansas City last week, did no more than uncover an apt term for corrosion it was worth while. When E. R. Needles characterized this bugaboo as "construction's common cold" he illuminated it beyond any descriptive light that technical language can throw on it. Corrosion is the biggest problem facing the engineering profession, just as the common cold is the medical profession's biggest problem, and neither has yet yielded to any prescribed treatment. There is, perhaps, one difference: the sufferer from a cold usually gets over it, but corrosion goes on and on. It is this fact that makes some effort to find a cure for corrosion so necessary and the A.S.C.E. symposium so important. For the speakers held out some hope that progress is being made. They did not agree unanimously but they did give a majority vote to thorough cleaning and dehydrating of the steel prior to first-coat painting. Important technologic progress in steel construction is recorded in the new methods of cleaning with the sandblast and the oxyacetylene flame, in new synthetic paints and most of all in a beginning of understanding of the corrosion process.

More to be Learned

SUCCESSFUL RENEWAL of the main cables of the Portsmouth Bridge is a feat of ingenuity and resourcefulness that reflects high credit on all concerned. It testifies also to the adaptability of the suspension type, for probably no other type of bridge would have lent itself to a comparable change of main members. The Portsmouth reconstruction was possible because of those qualities that make the suspension bridge efficient: its large reserve of strength and its ability to undergo change and adjustment.

Because of the popularity and recognized merits of the suspension type the questions presented by the extensive wire breaks that led up to the reconstruction call for thorough exploration. Many scores of suspension bridges have been in unimpaired service for decades, and the Portsmouth breaks cannot place the type as such under suspicion; they are without precedent. The apparently similar breaks of the Mount Hope and Ambassador cables a dozen years ago involved a heat-treated wire entirely different in character from bridge wire previously used, while the Portsmouth wire was of the usual cold-drawn kind.

Rusting was an undoubted factor of the breakage, as the laboratory report clearly suggests, and pitting may have additionally weakened the wire. For this reason, even in the face of the successful use of ungalvanized wire in the Williamsburg bridge cables engineers will be reluctant to use such wire in future. But unless rusting affords a complete explanation of the breakage it is necessary to know why the wire broke at the moderate tension of about 60,000 lb.—against a specified strength of 220,000 lb. per sq. in. and an actual strength up to 260,000 lb.—and why it broke after giving twelve years of satisfactory service.

Fundamental questions of steel and wire quality thus remain to be explored. Remembering that the wire was bought and accepted under normal, approved specifications, engineers will turn to the metallurgist and ask how wire shall be specified and tested in order to be proof against unforeseen failure of the kind here experienced. It may be hoped that the National Bureau of Standards will undertake an investigation of the problems involved and enlist in the work the aid of the best metallurgical laboratories in the country.

A Hopeful Prospect

A SEARCHING STUDY of the nation's confused transportation situation is in prospect through appointment of Owen D. Young as chairman of a transportation committee under the sponsorship of the National Resources Committee. It is a hopeful prospect, for the need for such a study has long been apparent.

When Joseph B. Eastman was appointed Federal Coordinator of Transportation in 1933 it was thought that his findings would produce the basis for progressive legislation, but when his three-year term expired his staff had not completed the collection of data, and only within the last few days has its final report been published. The Young committee will have these data to work on, hence its task may be one of analysis rather than of factfinding.

Lack of equality between the railroads on one hand and commercial truck operators on the other is a major source of transportation confusion. This finds its origin chiefly in the much more severe labor and safety requirements that the railroads must meet and in the artificial limits set by Congress on railroad consolidations. But banking houses and insurance companies also are seriously hampering the railroads by their efforts to salvage the full value of securities that are backed by property now largely obsolete.

Obviously, a proper solution of the transport problem is of great importance nationally; it is equally important from the more restricted viewpoint of the civil engineer and contractor. The inability of the great majority of our railroad companies to finance new construction has deprived engineers of a large amount of useful work and has checked the flow of much-needed new blood into the railway engineering field. Any change that would put rail and truck operations on a sound economic basis will ultimately call for the investment of a large amount of capital in new rail-truck terminals to replace those built to meet the limited range of horse-drawn vehicles.

The transport problem is no easy one to solve, but if men of the standing and experience of Owen D. Young are put on a committee to study it, and if Congress will act on their recommendations, it is far from hopeless.

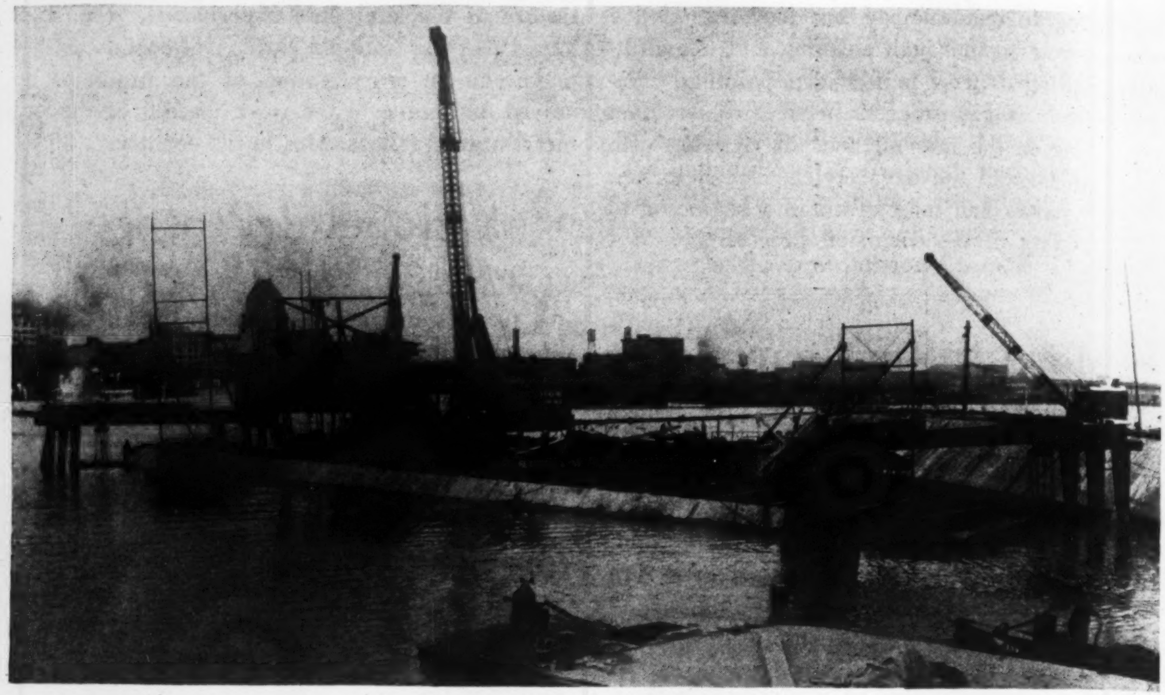


FIG. I. SINKING ONE OF THE TUBE SECTIONS FOR THE NEW VEHICLE TUNNEL AT MOBILE.

Mobile Builds a Vehicle Tunnel For Gulf Coast Highway Traffic

***Contents in Brief**—A single-tube vehicle tunnel 3,400 ft. long is now being built under the Mobile River at Mobile, Ala. Its approach sections are of box-type subway construction built in open cut; the river section is formed with steel and concrete tubes sunk to place in a dredged trench. A simplified ventilation system is used on account of the short length of tunnel.*

THE CITY OF MOBILE, ALA., is building a 3,400-ft. vehicle tunnel from the main business section of the city under the navigation channel of the Mobile River to a connection with the main highway along the Gulf Coast to the east of the city. It will cut 7½ miles off the present route to the east as the highway now goes north through the city to a bridge that crosses the river above the main ship channel and then turns south again to a point opposite the city before swinging east. A tunnel was chosen in preference to a bridge because it would eliminate all interference with ships moving to and from the Alabama State Docks. The new structure is to be called the Bankhead Tunnel.

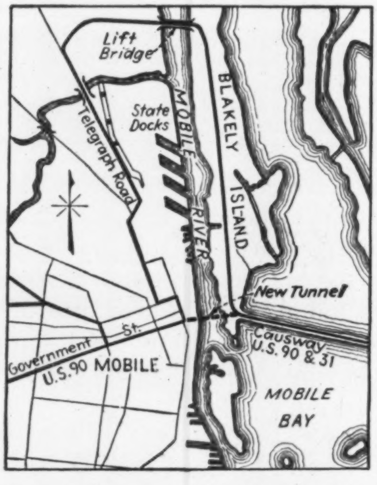


Fig. 2. The tunnel will cut 7½ miles off the main route to Mobile.

The tunnel starts in Government St. in Mobile, a wide street bringing U. S. Highway 90 in from the west, and comes up on Blakely Island to connect again with Highway 90 from where the route extends by bridge and causeway across the upper end of Mobile Bay to the mainland. Highway 31 to Montgomery and Birmingham follows same route.

Tunnel design

The tunnel is a two-lane tube having some notable variations from the usual design for such structures. The Mobile approach is an open ramp of reinforced concrete construction 280 ft. long leading down to rectangular steel-bent section that carries the tunnel under Government St. to near the waterfront. From there to the opposite side of the river the tunnel is carried in a steel and reinforced concrete tube sunk in a prepared trench. On the far side the tunnel again changes to a rectangular box type of structure which is carried up above ground to a vertical end wall which is to carry hurricane gates to protect the tunnel against flooding in time of storm.

Details of the tunnel are shown in Fig. 3. Its most notable variation from similar vehicle tunnels is the all-welded construction of its underwater tube, the elimination of an overhead air duct and the use of the duct under the roadway for exhaust air. Fresh air is taken in through the portals. There is only one ventilating building, located on Blakely Island, and it exhausts the air from the tunnel over a length of about 400 ft., 200 ft. each side of the midpoint between portals. This simplified ventilating system was adopted because of the short length of closed tunnel, about 3,100 ft. in all. Studies made by the U. S. Bureau of Mines show that although carbon monoxide rises in air when hot, it tends to fall when it cools, and will fall if there is a downward movement of air. In the Bankhead Tunnel, with traffic moving in both directions, air will flow down the inclines and into exhaust ducts through ports along the curbs of the roadway.

Another variation of interest is the elimination of a replaceable pavement, the top of the concrete roadway slab being belt-finished to form a concrete pavement. Curbs are of cast iron imbedded in the concrete. The roadway width is 21 ft.

Ducts for electric utilities are in the sidewalls, as usual, but are of asbestos-cement instead of steel or tile as in earlier tunnels.

An unusual element of the structure is the hurricane gate at the east portal on Blakely Island where storm tides may go 6 ft. above the roadway. The gate has two leaves, each hung from a trolley against the portal wall. In case of storm the gate sections will be drawn across the opening, locked together to form a tight central joint and drawn against projecting steel

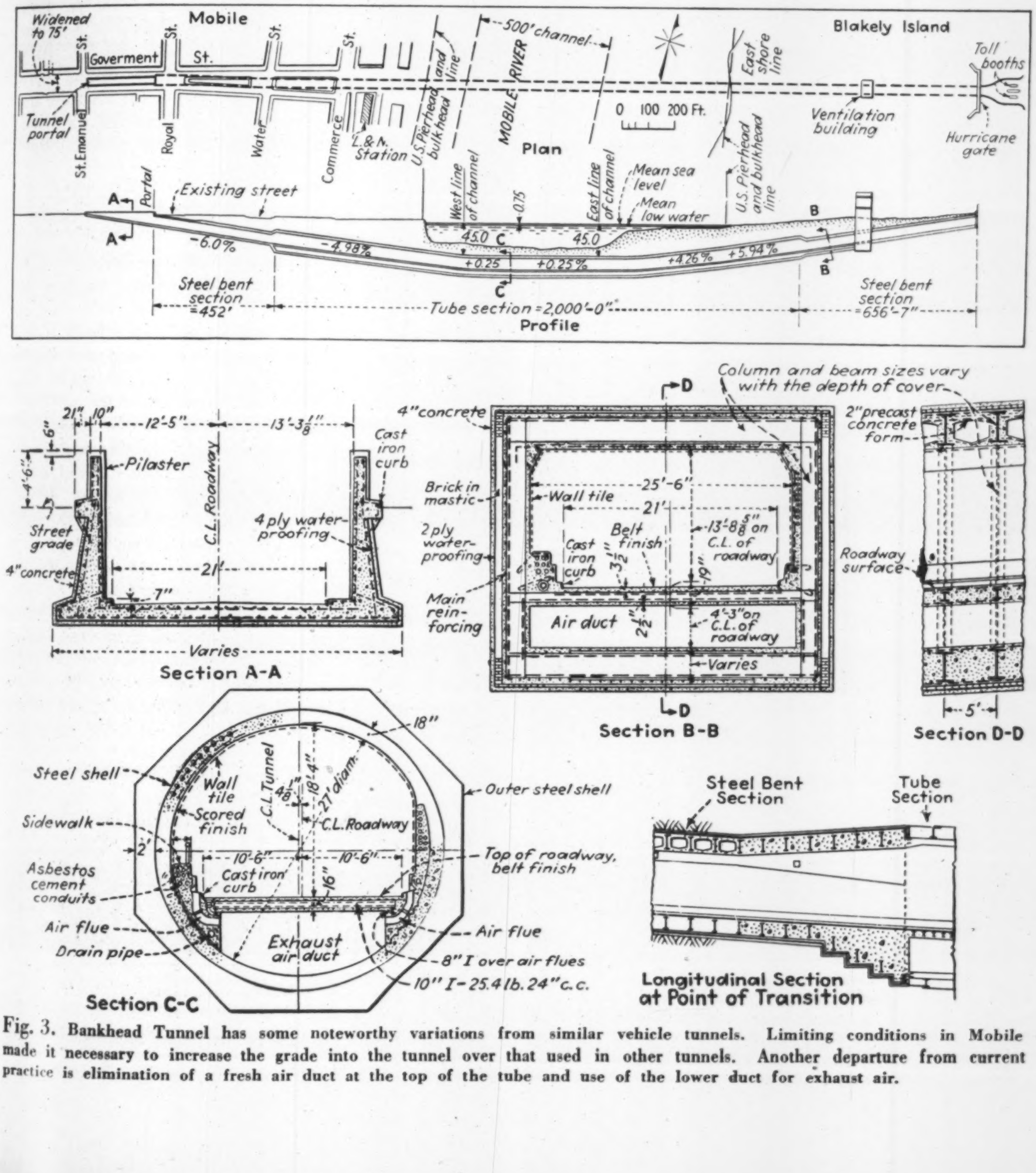
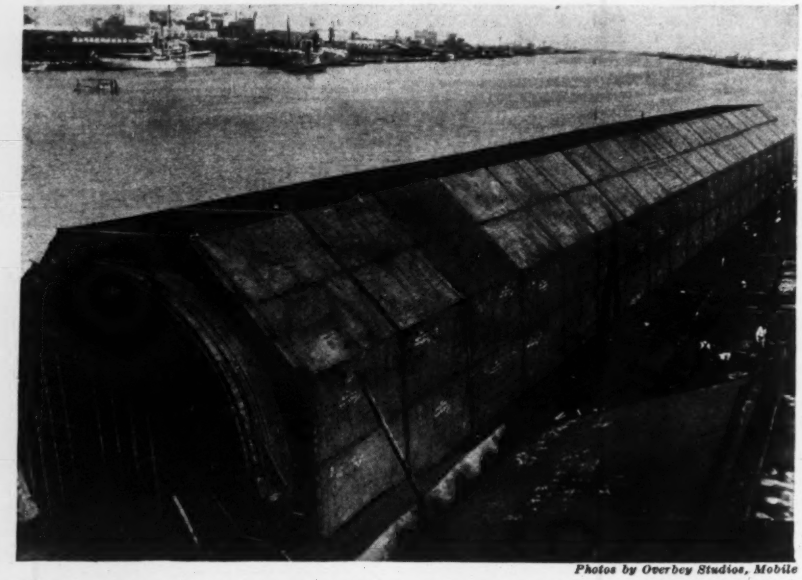

Widened to 75'
Mobile
Goverment St.
St. Emanuel St.
Royal St.
Water St.
Commerce St.
Tunnel portal
L.&N. Station
U.S. Pierhead and bulkhead line
500' channel
MOBILE RIVER
0 100 200 Ft.
Plan
East shore line
U.S. Pierhead and bulkhead line
Blakely Island
Ventilation building
Toll booths
Hurricane gate
A
Portal
Existing street
-6.0%
-4.98%
West line of channel
East line of channel
Mean sea level
Mean low water
45.0
0.75
C
+0.25
+0.25%
+4.26%
+5.94%
B
Steel bent section =452'
Tube section =2,000'-0"
Steel bent section =656'-7"
Profile
21" 10"
12'-5"
13'-3 1/8"
6"
4'-6"
Pilaster
C.L. Roadway
Cast iron curb
Street grade
4 ply waterproofing
4" concrete
21'
7"
Varies
Section A-A
D
4" concrete
Brick in mastic
Wall tile
25'-6"
21'
2 ply waterproofing
Cast iron curb
Belt finish
13'-8 5/8" on C.L. of roadway
3 1/2"
19"
Main reinforcing
Air duct
2 1/2"
4'-3" on C.L. of roadway
Varies
Section B-B
Column and beam sizes vary with the depth of cover
2" precast concrete form
Roadway surface
5'
Section D-D
18"
Steel shell
Wall tile
C.L. Tunnel
4 1/8"
18'-4"
27' diam.
Outer steel shell
Sidewalk
Scored finish
C.L. Roadway
2'
10'-6"
10'-6"
Top of roadway, belt finish
Asbestos cement conduits
Cast iron curb
16"
Air flue
Exhaust air duct
Air flue
Drain pipe
8" I over air flues
10" I-25.4 lb. 24" c.c.
Section C-C
Steel Bent Section
Tube Section
Longitudinal Section at Point of Transition

Fig. 3. **Bankhead Tunnel has some noteworthy variations from similar vehicle tunnels. Limiting conditions in Mobile made it necessary to increase the grade into the tunnel over that used in other tunnels. Another departure from current practice is elimination of a fresh air duct at the top of the tube and use of the lower duct for exhaust air.**



Photos by Overbey Studios, Mobile

Fig. 4. First section of the steel tube after being launched from the ways of the shipyard in which it was built. The cast shoe for engaging the seating pin of the second tube is shown at the side of the forward end.

plates at the sides and bottom to make these joints practically watertight. The top will be too far above high water to require a watertight joint.

Grades in the tunnel reach a maximum of 6 per cent. This was made necessary by two limiting conditions, first by a requirement that no street should be closed in Mobile or radically changed in grade, and second by a War Department stipulation that the top of the tunnel must be 45 ft. below mean low water in the navigable channel.

Tolls and costs

Toll booths are to be built on Blakely Island where all tolls will be collected. Toll rates have not yet been fixed. They will be designed to pay operating costs and amortize the investment in not over 30 years. The tunnel is being financed with a PWA grant of $1,500,000 and an RFC loan of $2,500,000, a total of $4,000,000. Work was begun in May, 1939, and is scheduled to be completed in July, 1940.

Ground conditions

Underground conditions are good throughout the tunnel length. The material is mostly a clean white sand of fairly coarse texture. Only near the Mobile bulkhead were conditions bad. There, all kinds of refuse, submerged timber and even rock ballast dumped from ships was encountered. For the open trench work, groundwater is lowered as much as 45 ft. in the coarse sand with wellpoints with little trouble.

The cross-channel trench, which goes to 81 ft. below water, was cut down to — 56 ft. with a suction dredge and then was completed with a bucket dredge.

Lining

Sidewalls and ceilings are to be faced throughout with tile of an off-white shade, $4\frac{1}{2}$x$4\frac{1}{2}$x$\frac{5}{16}$ in. thick, with a special clincher type back developed for the project by the United States Quarry Tile Co. of Canton, Ohio. Sidewall tile is applied to roughened concrete after the concrete lining is in place, but ceiling tile in the box sections are set in the forms for the reinforced concrete top. After the ceiling forms are in place the tile are laid on gummed paper, carefully spaced, the joints are filled with sand and a thin mortar is painted over the joints to seal the sand and hold it in place. Then a thick mortar is spread over the backs of the tile and concrete placing goes forward. Pointing of the joints is done after the forms have been removed.

Lighting

The lighting arrangements vary. In the rectangular approach sections, the lights are to be 200-watt lamps in sidewall recesses 30 ft. apart on each side. Near the portals, center ceiling lights of 750-watt capacity are added, beginning 20 ft. back from the portals, spaced on 5-ft. centers for 60 ft. and then on 10-ft. centers for 50 ft. These ceiling lights are auxiliary lights for daytime use to furnish a more gradual transition from daylight to the artificial light in the tunnel.

In the tube section the lights are to be pendants of 300-watt capacity on 50-ft. centers.

Drainage arrangements in the open cut on the Mobile side are designed to take a maximum rainfall at the rate of 4 in. per hour. Long catchbasins are provided and sumps adequate to hold the maximum runoff for 45 min. should the drainage pumps be put out of commission.

Two sources of power are to be provided, one at each end. In addition, a gas-engine generator set in the ventilating building will provide power for lights, pumps, and a limited amount of ventilation should both outside power sources be put out of service by storm. Battery service is provided to carry the lights during temporary loss of outside power. Power to operate the fans would not be needed in a bad storm

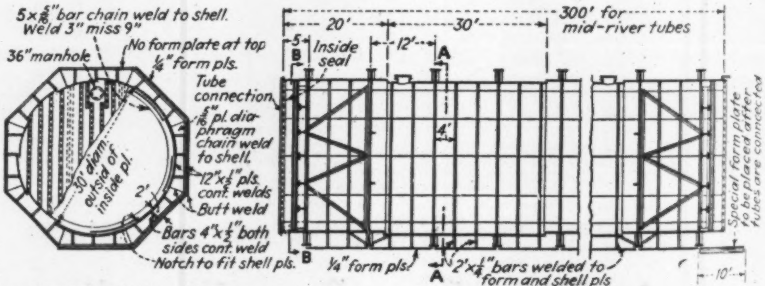

5x5/16" bar chain weld to shell.
Weld 3" miss 9"
36" manhole
No form plate at top
1/4" form pls.
Tube connection
5/16" pl. diaphragm chain weld to shell.
30' diam. outside of inside pl.
2'
12"x1/2" pls. cont. welds
Butt weld
Bars 4"x1/2" both sides cont. weld
Notch to fit shell pls.
Part Sections A-A and B-B
300' for mid-river tubes
20'
30'
5
12'
B
A
Inside seal
4'
1/4" form pls.
2'x1/4" bars welded to form and shell pls
Special form plate to be placed after tubes are connected
10'
Longitudinal Section

Fig. 5. Details of the steel tube sections showing the temporary bulkhead. Welding was employed throughout in building the tubes.

as the tunnel would be out of service.

Three sets of ventilating fans are to be installed, two for normal operation and one for spare.

Tube construction

The 2,000-ft. tube under the river channel is being built in seven sections, floated to place and sunk in a prepared trench. End sections are 255 ft. long and the other five are 298 ft. long.

Details of the tube sections are shown in Fig. 5. All the steel work for each tube was assembled by welding on the launching ways in the shipyard of the Alabama Drydock & Shipbuilding Co. on Pinto Island, less than a half mile from the site. As soon as a section had been completed the temporary end bulkheads were put in and 5 lb. of air pressure was built up on the inside. All joints then were washed over with soapy water and any leaks were welded. Very few leaks developed in the miles of welded joints required for the seven tubes, the last of which has now been launched.

When the testing has been completed the tube is launched and placed in drydock at the shipyard. There it is set upright and concrete is pumped in to fill the lower part of the space between the outer and inner shells up to the bottom of the vertical side plates of the outer shell. During the concreting, blocking is placed under the bottom plates to prevent distortion that might open up seams.

After the concrete has set the dock is flooded and the tube is towed to a pier about half a mile farther downstream and tied alongside. There the major part of the interior concrete, power and light ducts, piping, etc., is put in, working through hatches 18x26 in. cut through the plates near the top.

Concrete is not put in the crown of the arch because there is only a 26-ft. depth in the channel between the terminal and the tunnel site, too little to float the completed tube.

The tube next is towed to deep water at the site where the crown concrete is pumped in from the contractor's floating plant. Then the hatches in the inner shell are closed and welded and grout is pumped in through nipples left in the shell to fill up any voids between the concrete lining and the shell. Air again

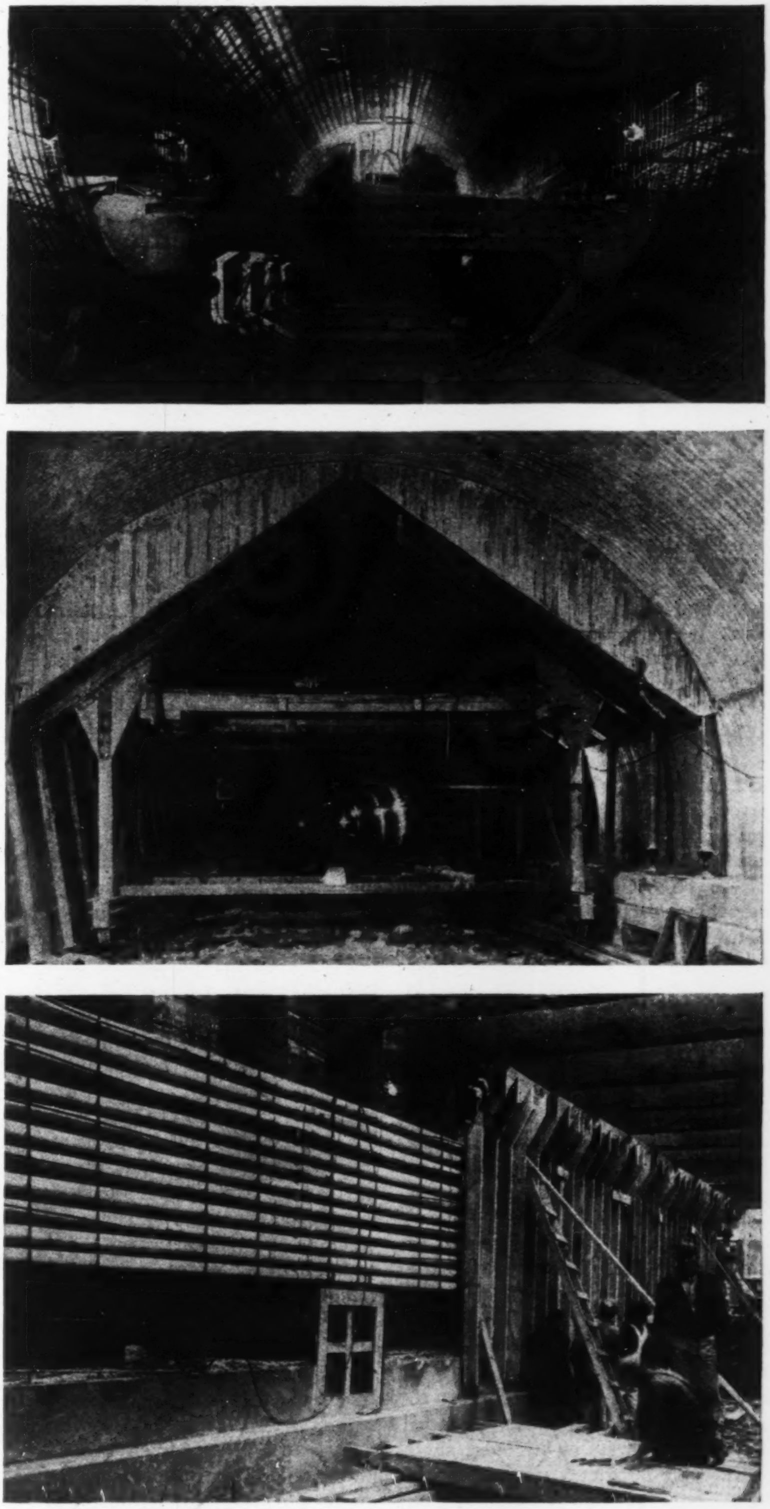


Fig. 6. The invert, floor and part of the sidewalls are put in before the tube is floated to place, working through hatches in the top (upper picture). The crown concrete is put on at the site, using a traveling form that is jacked up to place as shown in the center picture. The scoring on the concrete is done while it is fresh to provide bond for the tile. The lower picture shows the wall construction in the box section. Cable ducts in the wall are the asbestos cement pipe.

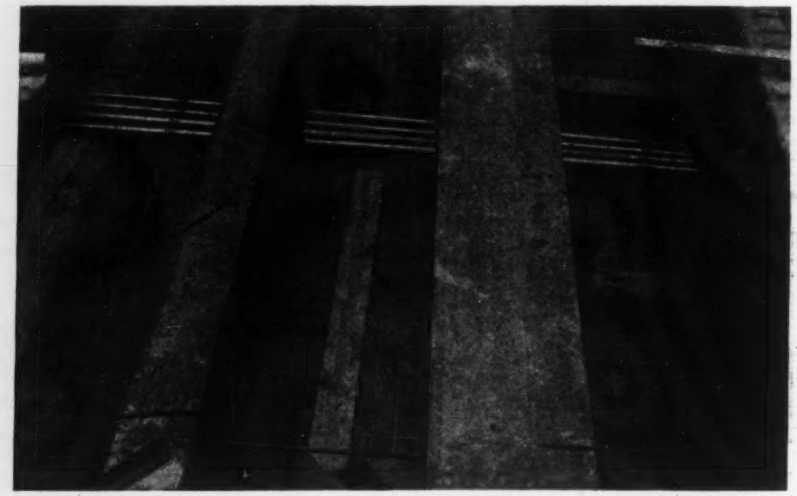


Fig. 7. Tile for the ceiling of the box section is set on the bottom of the forms. From left to right, the tile is first laid on gummed paper spread over the heavy plywood forms, sand is then poured into the joints to fill them and thin mortar is flushed along the joints to seal the sand and hold it in place. When this has set, thick mortar is spread over the tile back in advance of the concreting.

is applied and is kept on for 24 hours. When testing has been completed the tube is moved to its position over the trench across the river for the tubes.

The east tube was set first, before the approach section had been built. When the tube was ready to be moved into position, a gallows frame similar to those shown in Fig. 1, was constructed spanning the position to be occupied by its easterly end. It consisted of two clusters of 14-in. H-section piles, three vertical and three batter piles in each cluster, supporting I-beams carrying two 15-ton chain blocks. A third pile cluster also had been driven as the start of a second gallows frame at the west end of the tube. In moving the tube to position, its easterly end was nosed into the easterly gallows frame and then, working against the tide to prevent the tube from being swept against the northerly pile cluster at the west end, the tube was swung in against the latter cluster and made fast while the second cluster was driven to complete the gallows frame for the west end. Upon completion of the frame, the chain blocks at the four corners were made fast to lugs on the ends of the tube and the placing of concrete in the outer shell to overcome buoyancy was begun.

The same system is employed in sinking the other tube sections, but in setting adjoining sections, the gallows frame spanning the outer end of the tube in place is used to support that end of the adjoining tube and a new frame for the opposite end is built by the method previously described. Alignment is obtained by means of projecting pins on the end of one tube that drop into brackets on the other. When the pins are seated, divers hook steamboat ratchets on one tube over lugs on the other and turn up the ratchets.

The tubes are so designed that when they come together a projecting steel plate on one tube seats againset a hemp and rubber gasket in a recess in the other. After the tubes all have been set the temporary bulkheads will be cut out and each tube will be permanently connected to its neighbor by welding a steel plate across each joint on the inside.

When two tubes have been coupled, the gap in the outer form at the joint, shown in Fig. 4, is closed by dropping form plates into grooves left for that purpose and tremie concrete is placed between the tube and the outer plates.

The trench for the tube is dredged 2 ft. deeper than the bottom of the tube to make it possible to get a good bed of backfill under the tube. When the tube has been lowered to within 4 in. of its final position the trench is backfilled with sand up to the top of the sloping sides of the base section, struts being inserted between the top of the tube and the underside of the gallows frames to keep the tube from being raised by the backfill. The remainder of the concrete in the outer shell then is placed by tremie, the chains are released and the backfilling completed. The tube then settles to final position, the 4-in. computed amount of consolidation of the underlying material being very close to actual settlement in the tubes set to date.

The tube section at the Mobile end (Section 7) is to be sunk in a steel sheeted trench back of the bulkhead line. As it could not be maneuvered into place if the river sections were all in, it is to be brought in and anchored over its final position before sections 5 and 6 are towed into place. After they have been set it will be sunk to final position and covered with sand backfill. When this has been done the transition section between the tube and the box section will be built in the dry.

The rectangular box sections at the approaches are being built in open cut at each end, beginning at the portals and working down toward the river tube. The Mobile approach is being built in a steel-sheeted trench because it is in a city street. Both cuts are kept free of water by a wellpoint system.

Three sections of the tube have been sunk to place, one is ready to sink, two are at the Turner terminal having the concrete put in, and the last section was launched recently. It is expected that the tunnel will be ready to be opened by July 1 of this year.

The tunnel is being built by the city of Mobile. Wilberding & Palmer, Washington, D. C., are engineering and financial consultants to the city and are in charge of the engineering and contract work with Wayne F. Palmer, vice-president in charge, R. F. Schaefer, chief engineer and A. L. Ruefer, construction engineer. E. H. Hopson is project engineer for the PWA.

The principal contract is held by the Arundel Corp. of Baltimore, E. H. Burwell being supervising construction engineer. Other contracts are: the ventilating building, Harvey & Quina, Pensacola; ventilating equipment, Rust Engineering Co., Birmingham; electrical equipment, Miller Electric Co., Jacksonville; pumping equipment, A. M. Lockett & Co., New Orleans. The steel tubes were fabricated by the Alabama Drydock & Shipbuilding Co., Mobile, and the wellpoint system was supplied by the Complete Machinery & Equipment Co., Long Island City, N. Y.

A Water Supply Is Born

Farley Gannett

Gannett, Eastman & Fleming, Inc.
Harrisburg, Pa.

***Contents in Brief**—River floods, a PWA grant and the availability of an upland source of pure water led Harrisburg to abandon a filtered river supply and go to the hills for water. And one of the engineers who worked on the original plant 35 years ago is now building the new works. In his own inimitable way, Farley Gannett tells the story of what happened and how.*

It isn't often that an engineer helps to build a waterworks for a city and then 35 years later his firm designs and builds another one for the same city which throws the old one on the junk pile. I am now having that interesting experience. The old plant isn't being abandoned because it is not supplying good water but because the new source is better—the water will be pure, it will be cheaper and not subject to interruption by floods.

Someone is going to ask why the plant we built thirty-five years ago was selected and why that of 1939 wasn't built in 1904. That is a fair question and deserves a fair answer. Three million dollars looked like a lot more money to Harrisburg, Pa., in 1904 than does $1,600,000 in 1939. (There wasn't any PWA in 1904). And in 1904 we did not suspect that the Susquehanna River was ever going to rise in flood five feet higher than it did in 1889, which then was the greatest flood known in a century of record.

When I came to Harrisburg in 1902, the day after I graduated from Massachusetts Tech., that city of 50,000 people was using untreated Susquehanna River water, had a high typhoid death rate, and you had to shut your eyes and hold your nose when you drank the stuff or bathed in a tub of it. When it rained in the coal regions on the East Branch the water was black; when it rained in the agricultural areas on the West Branch it was yellow and when it rained over both branches at the same time we drank beer and stayed dirty.

James H. Fuertes, consulting engineer, had the job of finding, designing and supervising the construction of a new supply. Charley Hyde (now a professor at the University of California) and "Deb" DeBerard (now an editor on this journal) were the boss men on the job for Fuertes, and I was the underdog that got kicked around. I have ever since had deep sympathy for the youngster just out of college who has all the dirty work to do.

Early filter installation

Getting back to the waterworks of Harrisburg; our boss studied the possibility of a gravity supply from the hills to the north and east but found the cost prohibitive compared to the cost of filtering river water at the city's door. Filtration, which was then relatively new in waterworks engineering project. I felt that I was attracting wide attention. My graduation thesis at Tech was a compilation of data on filter plants and their results in reducing typhoid death rates. So I was enthusiastic over helping to design and build a filter plant. I could see myself as an important factor in this great life-saving engineering project. I felt that I was fortunate indeed at the start of my engineering career to be associated with this project which was going to remake the water supply of Harrisburg, save many lives and give so much satisfaction to the water consumers.

But as the underdog my important part in the work turned out to be designing pipe railings, roads around and in the plant, sewers and catchbasins and a beautiful 125-ft.-high brick chimney of which I have always been proud. The other fellows did the important jobs. For many years thereafter I have called attention of visitors to that lovely, graceful chimney, the one part of the filter plant that protruded above the dike around the plant, which was built to keep out floods. (Incidentally, it was the only part that could be seen of the plant when the flood of March, 1936, reached its peak.) The filter plant was built on an island in the river opposite the downtown section of the city and this dike was three feet higher than the highest flood in a century. What more could one ask for in conservative design?

This plant has given Harrisburg pure, clean water for more than three decades; we have been drinking it with pleasure and bathing in it with real results. Esthetically it has been probably the greatest improvement Harrisburg ever undertook and the water rates have remained exceedingly reasonable. Typhoid fever originating in the city, has practically disappeared. Whereas before filtration the typhoid death rate for several years averaged 28 per 100,000 per year, in the last 10 years it has averaged only 0.6 per year, and for five of these years there were no deaths among the residents of the city. It is perhaps not fair to give the water all the credit for this but it probably deserves much of it.

Something serious would have to happen to even suggest the possibility of abandoning such a water supply. Either that or some source with nearly perfect conditions surrounding it would have to be found to cause the citizens to approve spending money to replace the filtration plant. So it was not criticism of the water we were using that resulted in the change. It was a combination of a nearly perfect, nearby source, a gift of $1,250,000 from the PWA and the flood of 1936, that made the change advisable. If any one of these three conditions had been absent it is safe to

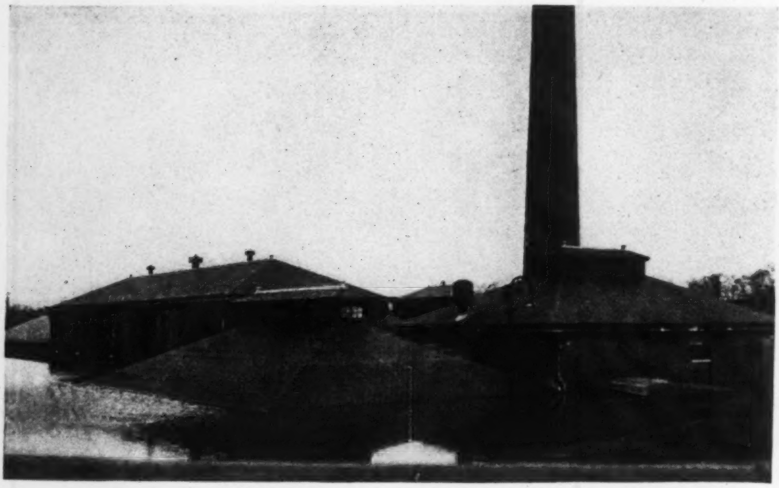


Fig. 1. One of the reasons why Harrisburg sought an upland water supply. This is the river filter plant as it looked in the flood of March, 1936.

say the project would not have gone through.

During the intervening 32 years between the completion of the filter plant and the flood of 1936, I had resigned my city job to take one with the state, followed Teddy Roosevelt in 1912 contrary to my bosses' orders, resigned my state job just in time to escape being fired, and then organized my own engineering business.

What the flood did

In March, 1936, a combination of the melting of deep snow and 3 to 4 inches of rain in three days over the whole Susquehanna River watershed of 25,000 square miles, resulted in a flood that overtopped our conservatively designed dike by 2 ft. and put the filter plant out of business and out of sight—that is, all but my stack. It was 10 days before the filters, buildings and machinery were cleaned, repaired and put in service again and during that time Harrisburg was on the verge of being without any water. Consumption was cut to the bare necessities and bathing was not a bare necessity. For several days the consumption of water was reduced from 11 to 5 mgd.

We assisted the city water department during this crisis. We watched the fall of the water in the 50,000,000 gallon distribution reservoir which was nearly full, fortunately, when the flood overtopped the dike. We also arranged for service with two private water companies, one supplying the eastern suburbs and the other supplying suburbs to the north of the city—these companies had sources of supply which were beyond the reach of the flood. Steelton, a town immediately to the south of Harrisburg and also situated on the east bank of the Susquehanna River, was able to maintain its plant in operation throughout the flood and by means of about 1,500 ft. of fire hose connecting hydrants in the two towns, was able to give water to the southern part of Harrisburg. A private water company supplying several suburbs across the river furnished water to a number of gasoline trucks loaned by one of the large oil companies, and this supply was hauled to the Harrisburg distributing reservoir for several days and nights. This was a dramatic publicity stunt but did not add materially to the supply.

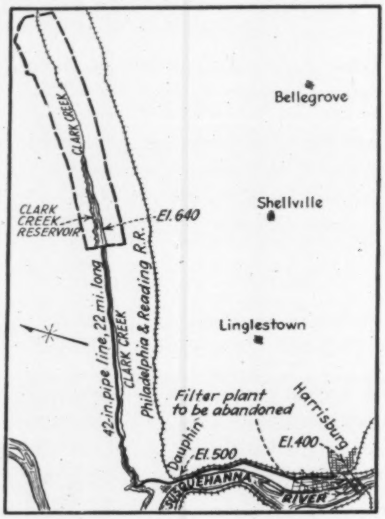


Fig. 2. A 100-ft.-high earth dam and a 22-mile reinforced concrete pipeline are the principal elements in the project.

Higher dikes

After the flood receded and the plant was again in working order the city asked us to design works to protect the filter plant and pump station from future floods. We designed some higher dikes but quarreled among ourselves as to how high they should be. Then as we couldn't agree on that, someone had the idea of compromising by trying to find a floodproof supply from the hills to the north and east of Harrisburg.

We started work on this idea, and about the time we had completed our report to the city and recommended spending about $3,000,000 thereon, along came the last PWA program. The city approved our scheme which recommended going to Clark's Creek, 20 miles to the northeast, building a 100-ft.-high dam storing 7 billion gallons of water and piping it by gravity in a 42-in. conduit to the existing

Fig. 3. The cleared reservoir area which will store seven billion gallons of water.

distributing reservoirs. This involved no pumping and no filtering. Off went an application to the PWA for a $1,250,000 grant and we got it—finally. But that's another story of "An Engineer in Wonderland;" perhaps it can be told some day, but not until the Clark Creek project has been completed and we know that no new complication will arise.

Check and double-check

In the meantime it was necessary for the citizens to vote on a bond issue to pay for the city's share of the cost, about $1,600,000. This election was held in November, 1938, and the Clark Creek plan was approved by a vote of over 7 to 1. There was a funny thing about that bond election. Although the city government, mayor and all four councilmen were Republicans, the two Democratic papers were heartily and enthusiastically for the scheme. The Republican paper, while not coming out flat-footedly against it, sat back and waited and kept its powder dry.

To make sure that the engineers employed by the city were right in recommending a new source of supply and that their costs were reasonable the city planning commission retained another firm of engineers to check our conclusions. And the state water and power resources board retained a nationally known authority to aid them in passing on it, while the state health department retained a consulting engineer to give his views of our conclusions. When all these authorities came out with reports approving our plans, apparently the whole city was convinced as shown by the vote for the bond issue. One trouble with the project was that it looked too good, and the people suspected something. Uncle Sam offered a present of $1,250,000; that was hard for some people to believe unless there was a string to it; there was said to be ample water in a stream which many people knew only as nearly dry in summer, which was the only time of year people had ever seen it. The stream's watershed was practically uninhabited and entirely forested and only 20 miles away. Since our plan called for storing the water two years before using it (the reservoir was to hold 2 years' supply) people thought that would make the water stagnant. It seemed a little fishy to some and many still think it may smell that way.

If the reservoir was to be as big as we said it was to be many voters thought that the stream would never fill it. Then when they heard the water would not have to be filtered, only chlorinated, they thought we were joking. It took the concerted approval from all the great authorities to convince the populace and some of its leaders that all was as we told them. A wave of approval swept over the voters when they learned that taxes and water rates would not be increased by the bond issue. That put on the finishing touch.

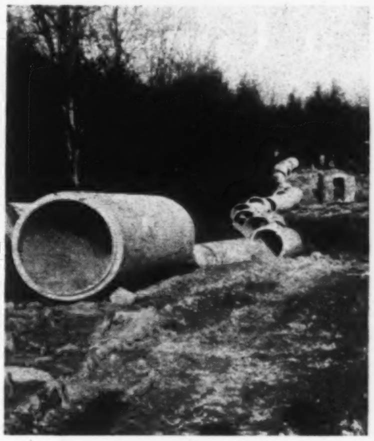


Fig. 4. Typical construction scene on the 42-in. pipeline.

A money maker

When this project is completed Harrisburg will have available a supply of 50 per cent more water than its daily needs require, coming from 23 sq. mi. of forested watershed; furthermore, it will flow by gravity and only chlorination will be needed. This scheme saves $115,000 a year in pumping and filtering costs, and as the city only has to put up $1,600,000 at 1.7 per cent on its bonds (out of the nearly 3 million dollars cost) the saving is sufficient to pay bond interest, amortize the bonds and then some. No more capital expense will be needed until 1990 when another nearby stream of the same character can be added.

We are now building an earthfill dam 100 ft. high with concrete conduit through and under the dam, a gate tower upstream of the center of the structure, and a control house below the dam housing chlorinating and other chemical apparatus. From this dam a 42-in. reinforced concrete pipeline, now under construction, will carry the water 22 miles to the distribution reservoirs in the city.

So why shouldn't the filter plant be junked? Polluted and dirty river water that had to be filtered is to be replaced by a pure, unadulterated mountain water. A reformed prostitute is being replaced by a virgin.

Softer water

The Clark Creek water is much softer than the present filtered Susquehanna River water and again being conservative we have determined that the 100,000 citizens of Harrisburg who will use this water will save nearly $100,000 a year in soap bills. It hardly seems possible to save that much soap and keep clean but the authorities all seem to indicate that this figure is about right.

In passing, I might say that if our ancestors who settled in river valleys had known as much about floods as some of us flood sufferers do now, perhaps they would have settled themselves higher up and out of the way of floods; much less damage would have resulted, and many costly flood detention reservoirs need not have been built. However, I am a poor one to criticize the old settlers as I built two houses which were under water in March, 1936.

In about a year Harrisburg will have for sale a nice mechanical filtration plant complete and in good condition with skilled operators. Much of the plant has earned its way and the bonds with which the original plant was built in 1904 are paid off. Contracts have been let for over $2,000,000 worth of new work (all below the original estimates) and present progress indicates that the job will be completed by the PWA deadline of June 30, 1940.

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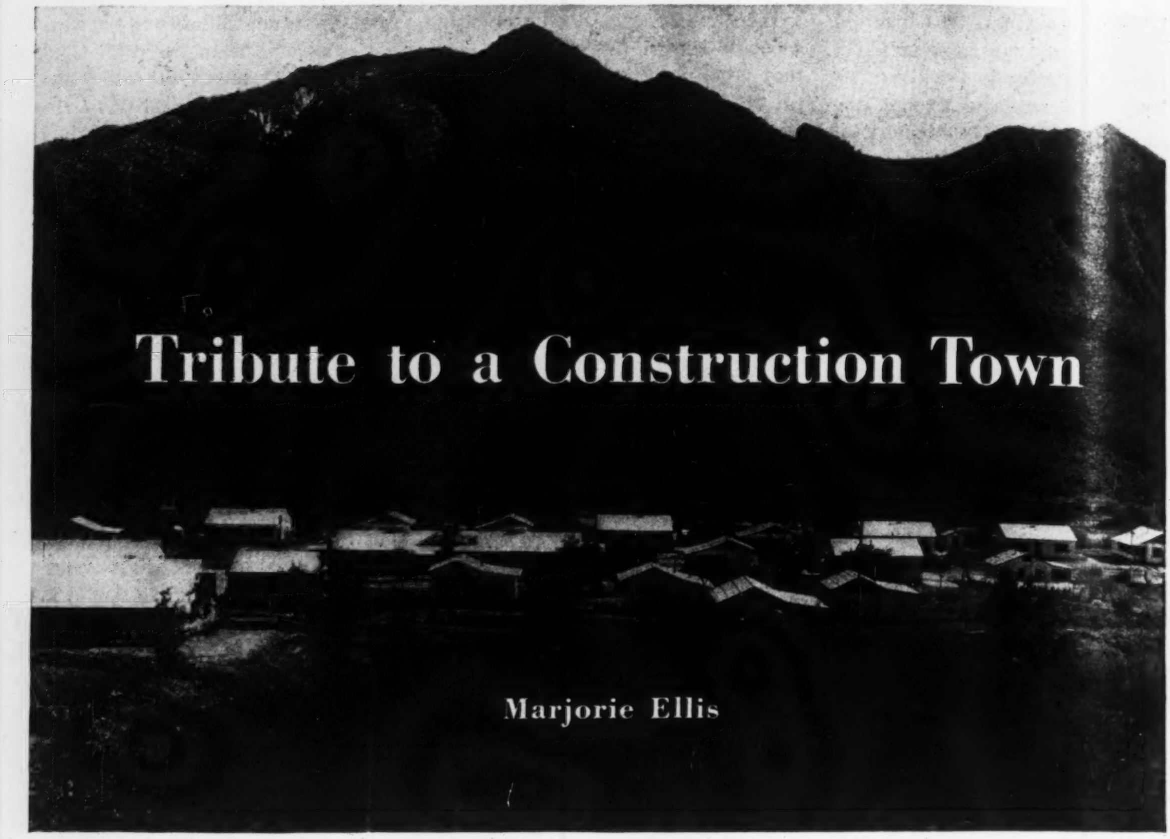
Color Slides Picture Indiana's Road System

Natural color slides have been prepared by the Indiana State Highway Commission to illustrate the varied operations and problems connected with the administration of the state's 10,000-mile highway system. The slides are being used by highway officials in talks before clubs and organizations interested in the state highway system, its development and the varied scenic beauty along roads in different parts of Indiana.



Tribute to a Construction Town

Marjorie Ellis

THE TOWN—HERE TODAY, ABANDONED TOMORROW, BUT AFFECTIONATELY REMEMBERED BY ITS ERSTWHILE DWELLERS AS HOME

***Contents in Brief**—Here is a story that has waited long to be written. Sincere, warm and friendly, it treats with understanding and affection that necessary adjunct of every remote job, the construction town. Built in a hurry, abandoned as quickly, such towns nevertheless have all of the virtues of the average permanent town—and often fewer faults. Mrs. Ellis has succeeded in expressing what many others must have felt about their own particular construction town, and she has unconsciously paid deserved tribute to the women who make these towns into "home towns" and thus contribute much to the success of the job. The story, which first appeared in the magazine "Arizona Highways", is one you will want your family to read.*

THE COUNTRY is full of them, the ghost towns, the towns that live on memories. Arizona has recently acquired a new one. No deserted mine, no empty shack, no bullet-riddled theatre will serve as a reminder of its living past. The land on which it was built will be swept clean of it, and it will stay alive only in the minds of the people who lived there. The symbol of their lives there—the slim, arching beauty of Bartlett Dam—will outlast even their memories.

The excitement and urgency of a big construction job drew us together from various parts of the country, and our town rose as quickly as it will vanish. But for all its brief life it ran the gamut of small-town experience. Eagerly the women waited for the completion of the trim green and white bungalows that were to be our homes. Fervently we argued with the carpenters over the number of closets and shelves we could have. We moved in when the varnish on the floors were scarcely dry, and the inevitable parting with our homes seemed far off. We hung curtains, we discussed color schemes and furnishings, and anyone would have thought to hear us that we were settling permanently. To one who has moved eighteen times in five years, two and a half years in one place does seem a fairly permanent arrangement!

The curtains hung, the rugs down, we gave a party. It was the first of many pleasant social functions at Bartlett Dam. There was the gleam of white linens and candles, and the tinkle of ice in crystal glasses, the laughter of well-dressed men and women enjoying an evening together. A dream, a mirage perhaps, it was so brief.

The women played bridge and drank tea together. They did their work, wheeled their babies out for an afternoon stroll and shopped at the commissary. A few brides began their housekeeping there. The men worked, and some of them died at their jobs. We had a newspaper, which the teacher and her pupils published weekly. There were Christmas programs at the school house, and a Sunday school met in the big garage.

We planted flowers and lawns. It isn't easy to plant flowers when one knows he won't be there to see them very long. I wonder how the desert will treat those two clumps of chrysanthemums I transplanted by the corner of the house. I laugh now when I remember how we all used to charge out into the night to chase The Bull from our garden. Someone would hear a snort, a satisfied crunch, and with a yell, "It's The Bull!" he'd grab the handiest weapon and tear outside. Where the bull came from no one knew; and he was charmed, that animal, for we never found anything that would really frighten him. He finally got Tom's corn just as it was ready to eat. Then they put a fence around camp and a first-class cattle guard at the gate, and our nightly diversion of chasing The Bull was no more.

The Indians, some of whom were laborers on the dam, lived on the wide banks of the river just below the cliffs which was our backyard. They built hogans of mesquite branches, cardboard, old doors, blankets and pieces of canvas. Their camp presented a motley appearance, but I sometimes thought it became a part of the environment more easily than ours did. Their presence always tinged our life with unreality. It was disconcerting to look from the window of my well equipped modern kitchen and see the smoke rising from their fires. Pleasantly their laughter and talk floated up to us. We could smell their food cooking. When the river was swollen with flood-waters, Indian women climbed the hill to get water from the tap in my yard. Fascinated, I watched them carry it back in huge tins atop their heads, their many petticoats swinging gracefully as they walked.

Someone with authority felt their nearness to the river was polluting its waters, so they were requested to move. One morning they were gone. Some weeks elapsed, and the incident was forgotten. Then one morning I looked out of my kitchen window to see the squaws matter-of-factly moving in again. The hogans were up once more. There they stayed.

The camp doctor must have a story to tell. He nursed us through epidemics common to small towns. He led my child, for one, safely through pneumonia. He treated scorpion bites and small accidents. He delivered babies, including premature ones for whom he built incubators in which he installed them safely. He cared for the injured when there were catastrophes on the job.

There was a night when his small hospital was crowded. We were reminded that night that we led no ordinary American lives. Our quiet evening was shattered by the shrill wail that rose from the camp. The dogs began to bark and howl, and that unhappy sobbing "Aiy, Aiy . . . Aiy, Aiy, Aiy," rose and fell as we looked at each other fearfully. Disaster . . . death it meant, I knew, but to whom and where?

When our men came driving back from the job, it was almost less shocking to hear their story of the rock-slide, and to see them wash the blood from their faces with the garden hose, than to listen to the mournful chant of the Indian women.

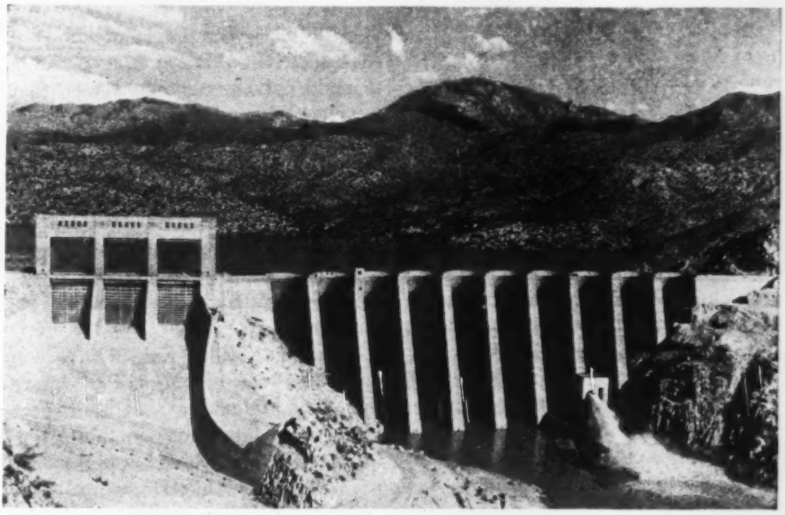
Jessie, my Indian wash-woman, said briefly, "My husband work on those rocks all day yesterday. The slide come just after he quit." I nodded to her. We were kin. "Yes, I know how you feel, Jessie. My husband worked there, too." Then we changed the subject abruptly, as construction camp women always do when such talk arises, though I always wondered if those red letters on the water tank reminded the men of danger as constantly as they did me. "Safety first," they screamed at us.

Ordinarily the Verde River is a small stream in a wide, dusty river bed. It was hard to believe stories we heard of its ability to rise suddenly and terrifically. We, nevertheless, were prepared for the drama of flood season. Excitedly, we splashed around in the mud and rain to watch it and listen to its roar. We stood about and speculated as to what it could do.

Before it was finished it had inspired considerable respect from us all. The people from the tent camp came flocking to the upper camp, bag and baggage, in the middle of the night. Cars were marooned. The catwalk was swept away as if it were made of match sticks. Men watched the forms on which they had worked for weeks twisted into useless driftwood. A heavy bulldozer tossed about in the muddy roaring current like a toy. The raging water hungrily ate up the truck loads of rocks dumped at the base of the mixing plant in an attempt to prevent its being torn loose from its foundation.

We washed our clothes in chocolate colored water and smelled the drying mud for some time after the flood was gone, and we lived on the excitement of it for weeks.

Summer came, and the thermometer went up, and up. Then we installed Arizona's distinguished and unique invention, the home-constructed air-cooler. That wonderful device appeals to the inventive in men, and all after-work discussion was devoted to arguments as to the proper construction of it. Most of the men were better engineers than they were carpenters, so there was a variety of coolers, and it was a point of honor with each family to defend its own. I think they were all very effective, and ours ran constantly though I sometimes felt it was a little noisier than the others and that I might be-



The job—reason for the town's existence, and remembered with joy or sorrow, whichever fate meted out to the families of the men who built it.

come "stir-crazy" from the incessant whir of the electric fan.

Construction wasn't limited to the dam, the houses, and the coolers. Some of the men built play-houses for their small daughters. One engineer fulfilled a dream and built himself a little house which he used as a dark-house for developing pictures. It was a favorite amusement for the rest of the camp to stand and jeer at the would-be carpenter.

Our little children led a beautiful life at Bartlett Dam. We were free from the worry of heavy traffic so they wandered at will from one yard to the other. They did not fear the rattlesnakes and scorpions as their mothers did. Shudderingly we learned what we must do if one of them got bitten and the doctor was not near. Their guardian angels did their work well. Although we saw many snakes and scorpions in and around camp none of our children was bitten.

The children organized frog-hunting expeditions and I will long remember my three-year-old daughter's look of pain and disgust when I could not bring myself to pick up one of the frogs gaily escaping from her share of the loot! He was big and fat, and his long legs dangled from her small, fat hands. Wearily his eyes blinked up at me. My guest from town took one horrified look. "You'd better get that child back to civilization," she said. The child is back, now. And she still likes frogs.

I will never go back to Bartlett Dam. I don't want to see what the desert did to my chrysanthemums and Lin's oleanders. I couldn't bear to see Julie's and Sandy's deserted sandpile. I wouldn't like to see the tangled remains of Mister Jake's beautiful flower garden. I have no more curiosity about the dam, which was once just a big hole in the earth, then a skeleton over which men crept carefully day and night. Then there's the swimming pool whose depths at least one mother will never forget.

We are all gone from there now, scattered once more all over the country, and the finished perfection of the largest multiple arch dam in the world is the only monument to our town. Bartlett Dam is a ghost town, except to us who lived there.

Permanent Painting Scaffolds For the Golden Gate Bridge

RUSSELL G. CONE

Engineer,
Golden Gate Bridge and Highway District

Contents in Brief—When Golden Gate Bridge was under construction the cost of painters' scaffolds under the stiffening trusses almost equaled cost of painting. The four permanent scaffolds now used for painting and maintenance were designed for a high degree of safety, easy access to the structural steel to be painted and convenience in moving.

As THE GOLDEN GATE BRIDGE is a deck structure, only the handrailing is above floor level and structural steel in the stiffening trusses is accessible only from some form of scaffold suspended beneath the floor. In planning for paint maintenance, it was recognized that the exposure to frequent salt fogs, usually with wind, and the height of 220 ft. above water level made it worth while to give special attention to maintenance scaffolds. Studies of scaffolding methods heretofore used on other bridges developed nothing suited to the requirements of this structure. In fact, the first painting (during construction) was done on scaffolds that cost almost as much to erect as did the actual painting operation itself.

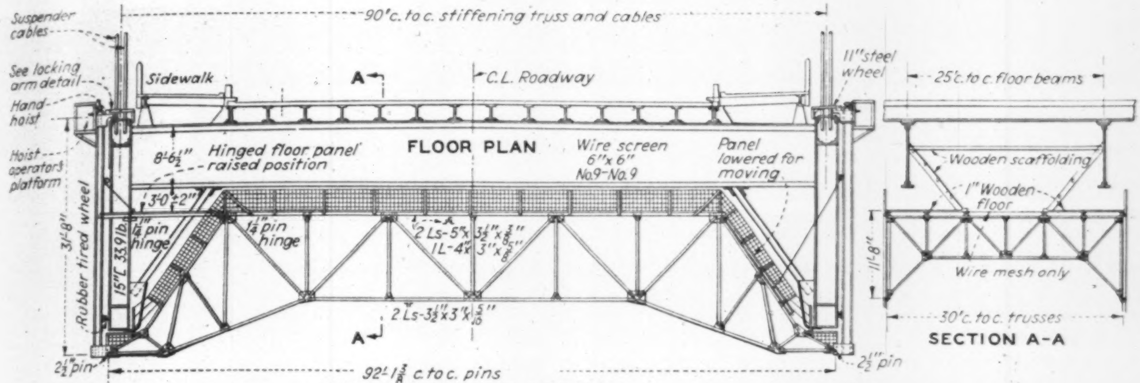
Accordingly, a new design of maintenance bridge was developed somewhat following the method of suspension and propulsion used on a traveler with which the safety net was slung under the bridge during steel erection. Had it been possible to make advance arrangements, that traveler, with some changes in original design, could have been adapted to the functions of a permanent maintenance bridge. As it was, the experience of the contractors who erected and painted the structure was of considerable aid in working out a design well suited to maintenance requirements.

When the Golden Gate Bridge was opened to traffic in May, 1937, more than $130,000 had already been spent in paint maintenance—an indication of the rapidity with which the first paint coats were deteriorating. This condition is believed to have been the result of not making special provision for the extremely severe exposure at this location by removing all loose mill scale from steel surfaces prior to erection.

It is now becoming quite generally the custom among bridge engineers to specify that mill scale shall be removed by flame cleaning, sandblasting, or other special treatment from the steel surfaces prior to erection. At the time the specifications for the Golden Gate Bridge were written, flame cleaning was hardly known and not in practical use. Sandblasting was very costly. The use of the sandblast was discussed by the board of engineers of the district early in the construction period, but since no funds were available, the additional cost of sandblasting could not be met. Paint failures caused by loosened mill scale unquestionably have added greatly to early maintenance painting costs and have attached special importance to the paint maintenance program.

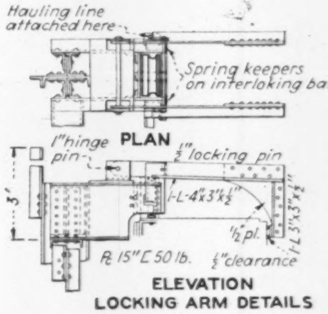
Soon after completion of painting that was done under the construction contract, inspection developed the fact that the surface of the entire suspended structure was generally pitted with rust. Before further painting could be done in a way that would last, it was necessary to remove practically all paint previously applied so that rust and scale beneath it could be taken off. After the surface of the steel had been properly cleaned, a priming coat was put on that could be expected to afford a firm and permanent base for future paint coats.

With this prospect for immediate


Suspender cables
See locking arm detail
Hand-hoist
Hoist operator's platform
90'c. to c. stiffening truss and cables
Sidewalk
A
C.L. Roadway
11" steel wheel
25'c. to c. floor beams
8'-6½"
Hinged floor panel raised position
FLOOR PLAN
Wire screen 6"x 6" No.9-No.9
Panel lowered for moving
Wooden scaffolding
1" Wooden floor
3'-0
2"
1¼" pin hinge
1¼" pin hinge
2 Ls-5"x3½"x⅜"
1 L-4"x3"x⅜"
31'-8"
Rubber tired wheel
15" L 33.9 lb.
11'-8"
Wire mesh only
2 Ls-3½"x3"x5/16"
A
30'c. to c. trusses
SECTION A-A
2½" pin
92'-1⅜" c. to c. pins
2½" pin

CROSS SECTION OF BRIDGE

Details of one of the four permanent traveling scaffolds used chiefly for painting.


Hauling line attached here
Spring keepers on interloking bar
PLAN
1" hinge pin
½" locking pin
3'
1-L-4"x3"x½"
½" pl.
1-L 5"x3"x½"
Pl 15" [50 lb.
½" clearance
ELEVATION
LOCKING ARM DETAILS

and extensive maintenance work as soon as construction was finished, it was necessary that permanent maintenance scaffolds be provided as quickly as possible. Several studies of scaffolding methods on other bridges developed nothing satisfactory and a new design was made.

The top cords of the stiffening trusses afford the most convenient support from which to suspend the scaffolds. Hence the length of the scaffold was naturally fixed by the stiffening truss spacing which is 90 ft. A scaffold of this length required a substantial width for stability in moving and the logical width was one panel of the stiffening truss; hence the scaffolds were made 30x90 ft. As painting operations will be practically continuous, the scaffolds will have to be shifted only about 25 ft. at each move; this made a power drive unnecessary and hand operation was provided for.

Convenience in operation suggested putting the scaffold platforms slightly below the bottom of the floorbeams and providing movable work platforms that can be swung into place to give access to steel between the floorbeams. These platforms, transverse to the suspended scaffold, are 16 ft. long and are raised and lowered by means of hand crabs. All horizontal space not occupied by parts of the scaffold was covered with steel wire mesh and wire mesh railings were put around the edges to enhance safety.

The 30-ft. width made it easy to devise ladders and scaffold planks that would support workmen at the various heights convenient for work on the underside of the floor slab. The planks are simply placed on wide ladders which lean against the floorbeam webs and stand on the scaffold deck. The ladders are prevented from slipping along the floor by 2x4 toe-boards.

The scaffolds were designed for uniform live load over the entire floor of 10 lb. per sq.ft.; stringers were figured for uniform live load of 30 lb. per sq.ft. Other load assumptions were a maximum live load on the center panel of 30 lb. per sq.ft. in addition to a uniform live load over the entire scaffold of 5 lb. per sq.ft. Similar assumptions were made for a concentrated live load for each panel of the scaffold.

Each scaffold is supported on four trucks, located at the corners, each with a single grooved wheel of forged steel. The groove in the wheels allows them to pass over the row of rivet heads which marks the outside gage line along the top flange of the upper chord. The axles are provided with roller bearings.

To move a scaffold, a line from one of the two hand crabs is passed ahead to and through a gate block attached to the suspender group two panels ahead. The becket of the line from the crab is then hauled back and attached at the front end of the scaffold to a shackle directly in line with the truck so that the lead of the pulling line is almost directly ahead.

By providing two locking arms at each point of support, it is possible to release and raise one, from moving ahead past a hanger, and still keep the second arm in place to prevent the scaffold from getting off its track. A notable safety feature is the use of interconnected locking pins with spring keepers. The locking pin can be pushed out of either locking arm thus making it possible to raise that arm, but it cannot be made to release both arms at once (see drawing).

Four scaffolds were provided, at a total cost, installed, of $37,837. One scaffold was put in each side span and two in the 4,200-ft. span. A scaffold can be moved ahead one 25-ft. panel in one hour, including time consumed in stowing the ladders and scaffold planks, taking down the movable end platforms, moving the structure one panel and replacing the movable platforms ready for work. The maximum number of men that may work on a scaffold at one time is fifteen and not more than 1,000 lb. of paint is permitted to be stored on one scaffold.

The four scaffolds have been in use for more than a year and a half and have made it possible to do a great deal more painting with the limited funds available than could have been done had no special scaffolds been provided. A substantial saving has been effected, too, on compensation insurance premiums which reduced, when the permanent scaffolds were installed, from $28 to $11 per $100 of payroll.

Experience with these scaffolds has demonstrated that when men are provided with a safe and convenient place to work, they accomplish a great deal more than if they have to hang on with one hand and paint with the other.

Delaware Aqueduct—II

Routing The Tunnel

***Contents in Brief**—Following out the general plan of the new Delaware water supply project explained by Chief Engineer Charles M. Clark two weeks ago (ENR, April 11, 1940, p. 513), it became necessary to lay the route of the 85-mile rock tunnel in such a manner as to provide interconnection with the Catskill and Croton systems and at the same time assure good rock conditions and flexible, efficient operation. The great depth of the tunnel was fixed by the desire to have the overlying weight of rock exceed the pressure of water in the tunnel.*

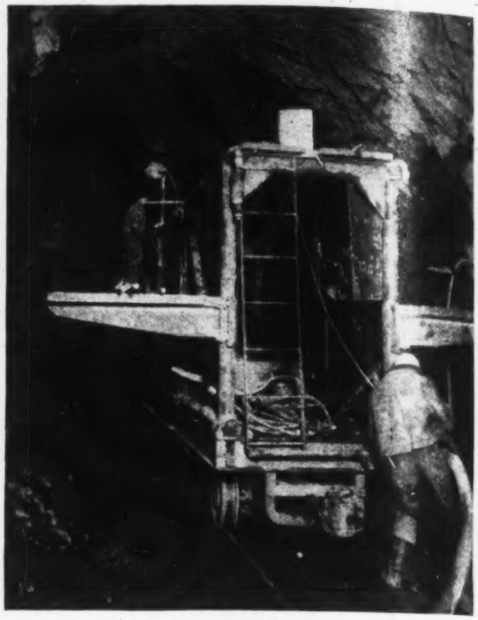


Fig. 1. **At depths of 300 to 1,000 ft. below ground the Delaware Aqueduct tunnel is being driven through solid rock for its full length of 85 miles.**

The new Delaware water system will comprise three aqueducts: the main Delaware aqueduct from Rondout storage reservoir at Lackawack in the Catskill Mountains to Hill View distributing reservoir at the northerly limits of New York City, and two feeders to deliver water respectively from East Delaware reservoir and from Neversink reservoir into Rondout reservoir. All three aqueducts will consist wholly of concrete-lined tunnel in rock. The two feeders—the East Delaware-Rondout tunnel, about 26 miles long, and the Neversink-Rondout tunnel, about 6 miles long, piercing the divides between the respective watersheds—have not yet been begun; they will be grade tunnels of relatively small diameter, to be driven from both portals and from five and one shafts respectively. On the other hand the main aqueduct, now under construction, will be a deep-lying pressure tunnel, circular in section and lined with concrete on its full length of 85 miles. Together with its southern extension, City Tunnel No. 2, which has been in service as an auxiliary distributor of Catskill water since March 31, 1936, it will make a continuous deep pressure tunnel in rock 105 miles long. The total length of tunnels in the Delaware system, including its distributing tunnel within the city (City Tunnel No. 2), will be 137 miles.

Five controlling points

The general route of Delaware Aqueduct (see Fig. 5) was fixed by five controlling points: the intake at Rondout reservoir; West Branch reservoir of the existing Croton system, which because of its high elevation is to feed into the new aqueduct; Kensico reservoir of the Catskill system, the main balancing reservoir of the city's supply; the Eastview filter site west of Kensico reservoir, where the Delaware water may later be filtered; and the Hill View distributing reservoir.

In explanation of the controls below the point of intake it should be said that routing through the Croton watershed offered several decisive advantages: (a) additional time of reservoir storage for sedimentation and reduction of bacterial content was obtained by passing the water through the 10,000-mg West Branch reservoir; (b) opportunity was had to pick up about 100 mgd of water from the higher Croton reservoirs and deliver it into Hill View reservoir at an elevation 160 ft. higher than it is now delivered through the two Croton aqueducts, both of which are supplied from the lowest of the twelve reservoirs of the Croton system; (c) the new aqueduct if so located would provide a third conduit from the Croton watershed to the city to safeguard an important part of the supply in the event of accident to either of the Croton aqueducts, now about 100 yr. and 50 yr. old respectively; and (d) this route assured greater flexibility of operation of the entire water supply system.

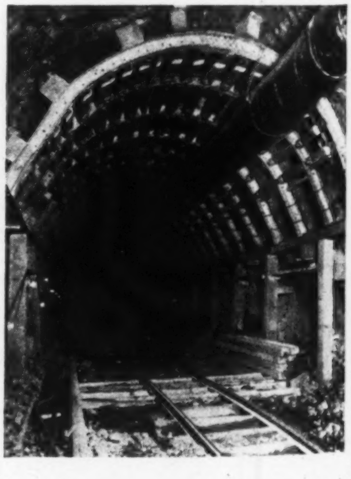


Fig. 2. **Nearly half the total length of tunnel has been driven to date. At the point shown, near Shaft 5A, the roof is supported by 8-in. H-section wall plates and 6-in. H ribs 4 ft. center to center, with 6-in. channel lagging.**

Routing through Kensico reservoir was desirable to get the benefit of additional sedimentation, and it was necessary to make available its 30,000-mg of reserve storage near the city, in event of a shutdown of the aqueduct farther north. Also some miles west of Kensico, at Eastview site, the city owns land suitable and sufficient for the construction of filters for both the Delaware and the Catskill systems, when such filters shall appear necessary.

Finally, at the southern end of the line, Hill View reservoir will be the distributing reservoir for both the Catskill and Delaware systems, and it will be the feeding point for the two city tunnels (of combined length under the city of 38 miles) which now deliver Catskill water and will deliver Delaware water to 37 underground valve chambers at widely spread primary distributing points. These underground valve chambers, affording 122 connections of 30-in., 36-in., and 48-in. diameter, feed into trunk mains, many of them 48 in. to 72 in. in diameter and up to 12 miles long, which in conjunction with additional future trunk mains will deliver the new water to the feeders of the distribution grid and to distant local distributing reservoirs.

Factors of detail location

Details of the location of the aqueduct between these five controlling points were determined mainly by considerations of geology, to keep so far as possible in good tunneling ground; of topography to afford suitable and accessible sites for properly spaced shafts of minimum depth and in good material, with adequate space for contractor's plant, available water supply, drainage for sewage from contractor's buildings and for water pumped from the tunnel, and facilities for the inoffensive disposal of spoil; and of real estate and land occupancy, to avoid so far as possible the purchase of costly land for shafts, to place shafts where possible on city land, and to avoid highly developed residential neighborhoods where construction operations might be an annoyance to the neighbors. The necessity for ample facilities for disposing of the large quantities of water to be pumped when unwatering the tunnels affected the location of the three drainage shafts, 6, 13 and 23.

From Rondout reservoir to West Branch reservoir, 45 miles through sparsely settled mountainous country, partly wooded and partly agricultural, it was found possible to locate the tunnel substantially on a straight line. From West Branch reservoir to Kensico reservoir a somewhat irregular line had to be followed because of geological conditions, high real estate values in a region of large country estates, the desire to place shafts near two other Croton reservoirs, and the opportunity to locate four of the six intermediate shafts (11, 12, 13 and 16) on land already owned by the city. From Eastview filter site to Hill View reservoir, a region in active suburban development and partly within the corporate limits of Yonkers, the location was designed to place shafts and tunnels in the best available rock and the least developed neighborhoods.

Catskill Aqueduct, whose length (from Ashokan reservoir to Hill View reservoir) is not greatly different from that of the new aqueduct, is predominantly a grade aqueduct, following the contour of the ground in cut-and-cover construction wherever possible and going through intervening hills as grade tunnel. Pressure types of aqueduct (tunnel or steel pipe) were used only for crossing valleys. Thus, 60 per cent of Catskill aqueduct is cut-and-cover concrete conduit, 15 per cent is grade tunnel, 18½ per cent is pressure tunnel, and 6½ per cent is steel pipe. The favorable relation of the topography to the general direction of the aqueduct made possible the high percentage of cut-and-cover aqueduct, the cheapest type.

Quite otherwise, the route of the 45-mile Rondout-West Branch section of Delaware Aqueduct is almost directly across the strike of the topography, a succession of high ridges and broad valleys of generally northeast-southwest trend. For about 17 miles the ground is far above the hydraulic gradient, necessitating tunneling. For about 28 miles the ground is far below the hydraulic gradient, necessitating some form of pressure aqueduct, and here the geological conditions favored a pressure tunnel. To avoid the complication of transitions between five-high-level grade tunnels and five deep pressure

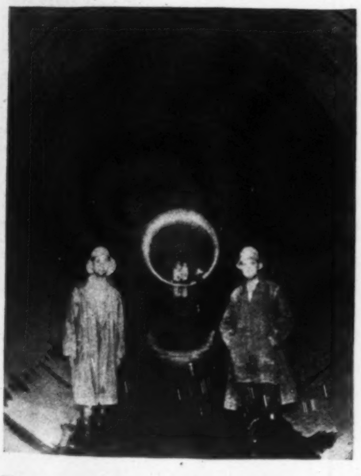


Fig. 3. Concrete lining produces a smooth, uniform bore within the rock excavation.

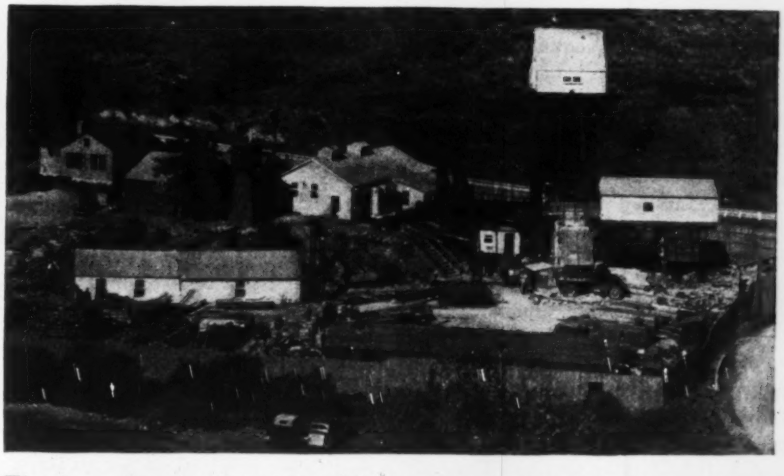


Fig. 4. At the top of the shafts from which the tunnel is driven, compressed air plant and other necessary facilities are provided. Minimum disturbance to the surrounding suburban area was sought in selecting the shaft sites.

tunnels with five sets of unwatering equipment, as well as for other operating advantages, the entire 45 miles was made a continuous pressure tunnel, whose maintenance requires only one unwatering or drainage shaft.

Right-of-way difficulties

Between West Branch reservoir and Kensico reservoir, where an aqueduct partly of the cut-and-cover type would have been physically possible, the difficulty and cost of acquiring the right-of-way for surface construction through this region of large private estates precluded a surface aqueduct. Between Kensico and Hill View reservoirs, through a region undergoing rapid suburban development, not only would these right-of-way difficulties have been even greater but the presence of another surface aqueduct would have been an unwarranted obstruction to future development. The pressure tunnel type of aqueduct avoided all interference with surface rights except for limited ground areas at the shaft sites.

The shaft sites where not on lands previously owned by the city, are spaced 2.1 to 2.6 miles apart between Kensico and Hill View reservoirs, 2.4 to 3.8 miles apart between West Branch and Kensico reservoirs, and 2.9 to 5.2 miles apart between Rondout and West Branch reservoirs. Between shaft sites the pressure tunnel required no land acquisition but merely purchase of an easement to build and maintain a tunnel.

Pressure tunnel advantages

The pressure tunnel type of aqueduct had two other advantages over a surface type of aqueduct—which so far as possible would be at the hydraulic gradient rather than under pressure. An all-pressure-tunnel aqueduct would give immediate response in rate of delivery at the downstream end to any change of gate opening at the supply reservoir, while a grade aqueduct would have a large time lag. Thus, in the present 75-mile Catskill aqueduct between Ashokan reservoir and Kensico reservoir about 21 to 24 hr. elapse between an increase in gate opening at Ashokan and the corresponding increase in delivery into Kensico, and in the 14 miles of Catskill aqueduct between Kensico and Hill View reservoir there is a time lag of 4 to 4½ hr. The immediate response obtained with a pressure tunnel will be especially valuable between Kensico and Hill View reservoirs, since it will make it possible to adjust the flow into Hill View reservoir immediately to the changing rates of consumption, in effect making Kensico reservoir another distribution reservoir and avoiding the costly enlargement of Hill View distributing reservoir which would have been necessary for satisfactory operation had the Delaware been made a grade aqueduct.

Finally, a deep pressure tunnel also affords the maximum of security against enemy artillery, bombing or sabotage.

Profile adapted to geology

The tunnel will be from about 300 ft. to about 1,000 ft. below the general elevation of the ground, and about 2,500 ft. below the crest of Shawangunk Mountain. Its profile (Fig. 5) was determined by the geology as revealed by exploration, surface reconnaissance and many miles of core borings. At many places notably under Rondout creek, Hudson River, and Kensico reservoir, and at several other places in the complicated geology between West Branch and Hill View reservoir, there are deep earthfilled preglacial gorges, or else faulted and deeply decayed rock; these conditions fixed the depth of controlling points of the tunnel profile, since the tunnel must be deep enough so that the cover of sound rock will resist without the use of a costly steel lining the internal water pressure, which in places exceeds 500 lb. per sq.in.

Between the controlling points fixed by the geology, the profile is laid out for convenience of construction and for drainage of the finished tunnel to selected low points, at which pumps will be installed in so-called drainage shafts for future unwatering, for inspection or repair. The deepest points of the tunnel invert referred to mean sea level are El.-600 at Shaft 6, fixed by the deep preglacial gorge of the Hudson river, and El.-660 in Kensico bypass at Shaft 18, fixed by deep decay at faults in limestone and gneiss under Kensico reservoir.

The entire 85-mile aqueduct, while practically a continuous tunnel, is actually divided into six sections, connected through gatehouses at the tops of their terminal shafts. These sections (Fig. 5) are the 45-mile Rondout-West Branch tunnel from Shaft 1 to Shaft 9; the 2.4-mile West Branch bypass from Shaft 9 to Shaft 10 under West Branch reservoir; the 22-mile West Branch-Kensico tunnel from Shaft 10 to Shaft 17; the 2.3-mile Kensico bypass tunnel between Shafts 17 and 18 under Kensico reservoir; the 1.8-mile northerly section of the 14-mile Kensico-Hill View tunnel, from Shaft 18 at Kensico reservoir to Shaft 19 at the Eastview filter site; and the remainder of the Kensico-Hill View tunnel to Shaft 1A North, which is the terminus of Delaware Aqueduct at Hill View reservoir.

Flow control

Control of the flow between successive tunnel sections is made at the surface gatehouses, in order that the gates may operate under the minimum head and be at all times accessible for inspection and maintenance. At the gatehouses at double Shaft 9 and 10 (the two shafts of each double shaft being the uptake from one section of the aqueduct and the downtake to the next succeeding section) the water can be sent either through West Branch reservoir or through the West Branch bypass tunnel. Similarly at the gatehouse at double shaft 17 and 18, water can be sent through Kensico reservoir or through the Kensico bypass tunnel. The water will ordinarily be routed through these two reservoirs, for the longer period of sedimentation obtainable in their 40,000 mg of combined capacity, but can be routed around either reservoir through the bypass tunnel whenever desired. The double shafts and gatehouse at Shaft 19 are to enable the water to be routed through the filters when these shall be built at this site.

The Delaware Aqueduct tunnels will be driven from 31 shafts* at 26 locations, the five locations cited above each having two shafts. Thirty of these shafts, from 314 to 1,551 ft. deep and of a total depth to tunnel grade exceeding 18,300 lin. ft., have been sunk and lined with concrete; another shaft, 341 ft. deep, has been sunk by one of the con-

* *ENR*, Jan. 14, 1937, p. 41. Borings completed subsequent to the date of that article have resulted in placing the tunnel deeper under Kensico reservoir, and other minor changes in shaft depths and tunnel elevations have been made.

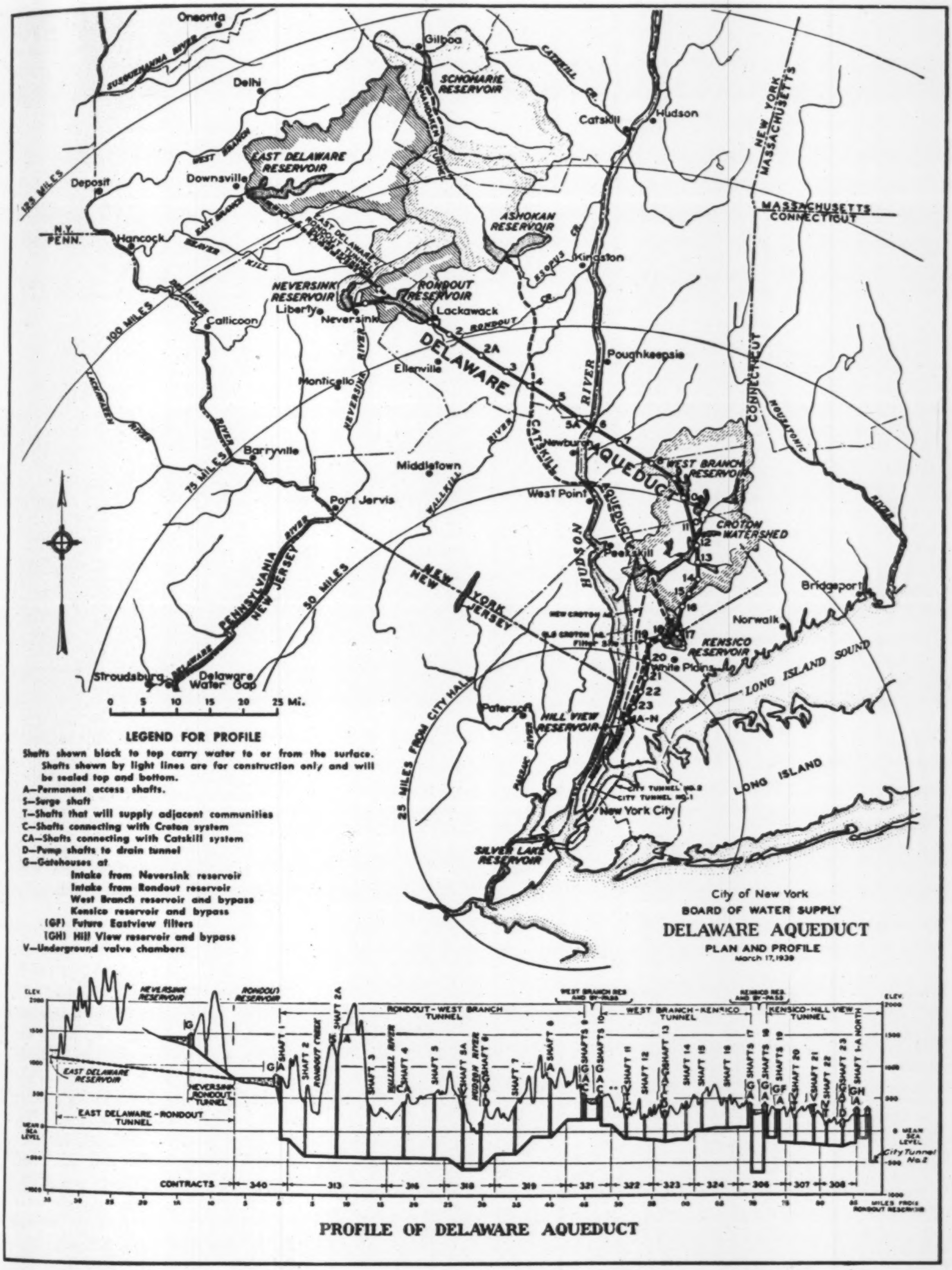

Oneonta
Gilboa
SUSQUEHANNA RIVER
Delhi
SCHOHARIE RESERVOIR
CATSKILL CR.
Catskill
Hudson
NEW YORK
MASSACHUSETTS
WEST BRANCH
EAST DELAWARE RESERVOIR
Downsville
Deposit
125 MILES
EAST BRANCH
ASHOKAN RESERVOIR
MASSACHUSETTS
CONNECTICUT
N.Y.
PENN.
Hancock
BEAVER KILL
EAST DELAWARE RONDOUT TUNNEL
Kingston
ESOPUS CR.
NEVERSINK RESERVOIR
RONDOUT RESERVOIR
Liberty
Neversink
Lackawack
RONDOUT
100 MILES
Callicoon
DELAWARE
2
2A
3
4
5
5A
6
7
Ellenville
Poughkeepsie
Monticello
NEVERSINK RIVER
RIVER
CONNECTICUT
HOUSATONIC
LACKAWAXEN RIVER
DELAWARE RIVER
CATSKILL
Newburgh
AQUEDUCT
WEST BRANCH RESERVOIR
Barryville
Middletown
WALLKILL RIVER
75 MILES
West Point
Port Jervis
CROTON WATERSHED
HUDSON
AQUEDUCT
Peekskill
RIVER
PENNSYLVANIA
NEW JERSEY
NEW YORK
NEW JERSEY
50 MILES
Bridgeport
NEW CROTON AQ.
OLD CROTON AQ.
Norwalk
KENSICO RESERVOIR
White Plains
LONG ISLAND SOUND
Stroudsburg
Delaware Water Gap
0 5 10 15 20 25 Mi.
Paterson
HILL VIEW RESERVOIR
PASSAIC RIVER
25 MILES FROM CITY HALL
CITY TUNNEL NO.2
CITY TUNNEL NO.1
New York City
LONG ISLAND
SILVER LAKE RESERVOIR
LEGEND FOR PROFILE
Shafts shown black to top carry water to or from the surface. Shafts shown by light lines are for construction only and will be sealed top and bottom.
A—Permanent access shafts.
S—Surge shaft
T—Shafts that will supply adjacent communities
C—Shafts connecting with Croton system
CA—Shafts connecting with Catskill system
D—Pump shafts to drain tunnel
G—Gatehouses at
Intake from Neversink reservoir
Intake from Rondout reservoir
West Branch reservoir and bypass
Kensico reservoir and bypass
(GF) Future Eastview filters
(GH) Hill View reservoir and bypass
V—Underground valve chambers
City of New York
BOARD OF WATER SUPPLY
DELAWARE AQUEDUCT
PLAN AND PROFILE
March 17, 1939
ELEV.
NEVERSINK RESERVOIR
RONDOUT RESERVOIR
WEST BRANCH RES. AND BY-PASS
KENSICO RES. AND BY-PASS
RONDOUT-WEST BRANCH TUNNEL
WEST BRANCH-KENSICO TUNNEL
KENSICO-HILL VIEW TUNNEL
EAST DELAWARE RESERVOIR
NEVERSINK RONDOUT TUNNEL
EAST DELAWARE-RONDOUT TUNNEL
SHAFT 1
SHAFT 2
RONDOUT CREEK
SHAFT 2A
SHAFT 3
WALLKILL RIVER
SHAFT 4
SHAFT 5
SHAFT 5A
HUDSON RIVER
SHAFT 6
SHAFT 7
SHAFT 8
SHAFTS 9
SHAFTS 10
SHAFT 11
SHAFT 12
SHAFT 13
SHAFT 14
SHAFT 15
SHAFT 16
SHAFTS 17
SHAFTS 18
SHAFTS 19
SHAFT 20
SHAFT 21
SHAFT 22
SHAFT 23
SHAFT 1-A NORTH
MEAN SEA LEVEL
City Tunnel No.2
CONTRACTS
340
313
316
318
319
321
322
323
324
306
307
308
MILES FROM RONDOUT RESERVOIR
PROFILE OF DELAWARE AQUEDUCT

Fig. 5. Delaware Aqueduct passes deep under the Catskill Aqueduct and the Hudson River, and taps high-level Croton waters on its course to the city. The East Delaware-Rondout and Neversink-Rondout tunnels, on which construction has not yet begun, will be grade tunnels of relatively small diameter. They will bring additional water from East Delaware and Neversink reservoirs to Rondout.

tractors at his own expense to expedite his work; and about 57 miles of tunnel, approximately 66 per cent of the total length, has been driven. The general rate of progress of full-section tunnel excavation for the 41 headings now active exceeds 6,000 ft. per week, an average of 650 ft. per heading per month. Headings have been holed through at three places and concrete lining of the tunnel has begun.

This article was prepared from data supplied by the late Walter E. Spear, chief engineer, and Leonard P. Wood, designing engineer, Board of Water Supply. *(The next article of the series will appear May 9, 1940. It will outline the conditions controlling the design of the tunnel, and the resulting structure).*

Plant for Electric Construction Tool Maker

***Contents in Brief**—Typical of small modern factory, plant of Skilsaw, Inc., Chicago, combines office and factory in connected separate units. Steel frame, concrete floors, brick walls, projected steel sash and timber roof are supporting and inclosure elements.*

DURING THE PAST FEW YEARS, when great advance has been made in industrial building design, the large factory has been given most of the credit. Innovation is, of course, easier on a large job where ample money is usually available, but advance in the small factory field is by no means lacking. A new plant recently occupied by Skilsaw, Inc., Chicago, manufacturer of such portable electric construction tools as saws, drills and grinders, for example, presents a striking contrast with most similar sized industrial building of the 1920's.

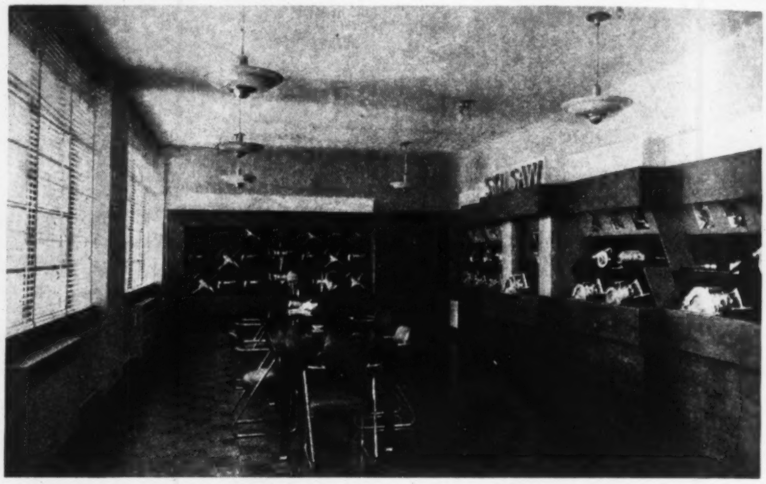


Fig. 2. **Conference room typical of construction and finish in the office building. Asphalt tile floor, acoustic ceiling, inclosed radiators, aluminum blinds, indirect lighting and nickel sprinkler fittings are features.**

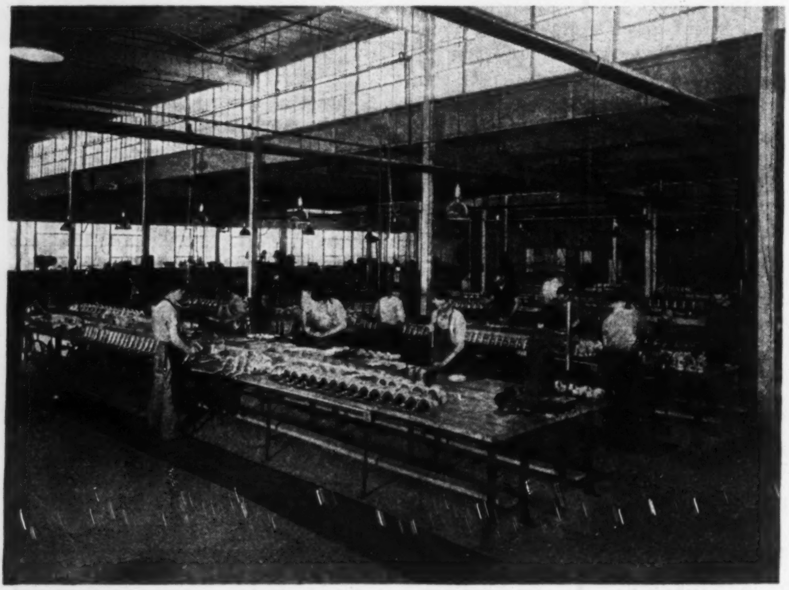


Fig. 1. **Assembly benches parallel monitors to provide even distribution of daylight. Machining operations are concentrated along wall of continuous sash in the background.**

Building layout

With a ground floor area of 140 by 200 ft., the new plant consists of a two-story section for offices and a one-story factory section. The office section extends across the 140-ft. front. In the factory, four 30-ft. aisles and one of 20 ft., which flanks an existing structure, have been provided. A riveted steel frame is inclosed in 12-in. brick masonry walls and steel sash of projected type. Floors are of concrete 5 in. thick, with concrete wearing surface in the factory, asphalt tile in the first floor office section, and half asphalt tile and half 1-in. maple floor in the second story. Main partitions are 6-in. tile, plastered on both sides. Offices are partitioned with dividing wood and glass.

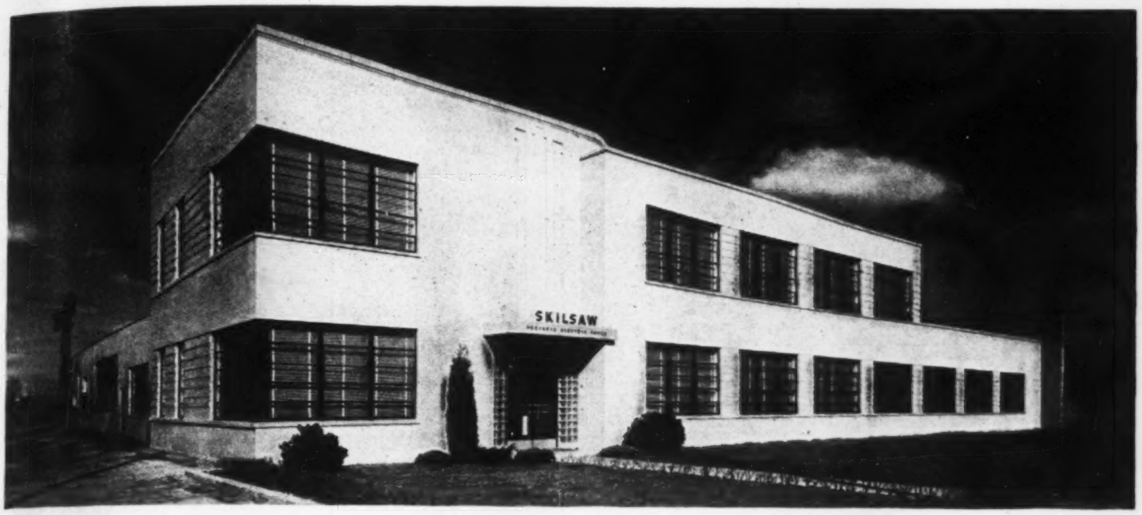


Fig. 3. **Brick details, corner windows, and glass block and stainless steel entrance give this new small factory a distinctive appearance. Sash is painted blue to contrast with buff face brick.**

In the factory section two monitors run the length of the roof which is framed in timber, with 2-in. wood deck covered with ½-in. fiber board insulation and 4-ply tar and gravel roofing. A 20-ft. working clearance is provided above the factory floor. Continuous sash incloses a temporary rear wall and provides ideal working conditions for the tool room and machining operations concentrated in this area. All machines in this section receive power through a bus distributing system which extends the full width of the building and permits the running of electric conduit overhead direct to each operating unit.

Benches upon which the company's products are assembled are laid out parallel to monitors to provide even distribution of daylight along their entire length. Permanent rubber floor mats are installed for the comfort of men working at these assembly benches. Plumbing pipe is of galvanized steel with malleable fittings and brass valves. A single source wet pipe sprinkler system is utilized, and heating is by hot water, radiators being used in the office section and suspended unit heaters in the factory. Lighting is from indirect fixtures.

Convenience for traffic

Careful thought was given to the location of offices experiencing the heaviest traffic. The purchasing agent is placed just a step from the entrance, and the plant superintendent just beyond him, with doors from his office into both the plant office lobby and the plant. Executives, sales and the general service department offices are on the second floor, as is the drafting room. Aluminum Venetian blinds and acoustic ceilings are features of the offices. Part of the first floor is a large display and conference room for the convenience of salesmen and customers.

The exterior of the building has been given a distinctive appearance by tying the large window areas across the two stories together with horizontal bands of brick. The entrance is featured by glass block at either side and vertical reveals in the brickwork just above the overhanging canopy of stainless steel. The plant was designed and built by The Austin Co., which has its main offices in Cleveland.

Cement Mixed with Mine Waters

MIXING CEMENT with acid mine water instead of normally pure water was investigated in a short series of tensile strength and acid immersion tests by the Bureau of Mines just reported (R.I. 3487, Jan. 1940, "Tests on the Effect of Acid Mine Waters on Various Cements," by R. D. Leitch and J. G. Calverley). The general result of the tests was to indicate that the use of acid mixing water had little effect on strength but that high-acid mixing water led to more rapid deterioration of slabs of cement immersed in mine water than did low-acid mixing water.

Three standard portland cements, one high-early-strength cement, a waterproof portland, a high alumina cement, a high silica and a high iron cement, were included in the test series. Using mixing water of two strengths (400 ppm and 8,570 ppm of acid respectively), tensile briquets at 7 days showed an increase of strength for the low-acid and most of the high-acid specimens over tap-water specimens; the 28-day results were slightly less favorable. The reporters say that "The tests do not reveal whether the actual improvement was due to accelerated setting only and might be reversed by long term aging in mass concrete."

Small slabs of neat cement mixed with mine water of 400 ppm and 2,300 ppm acidity, immersed for 510 days in mine water, showed more rapid deterioration in the case of the high-acid mixing water than in the test where low-acid mixing water was used.

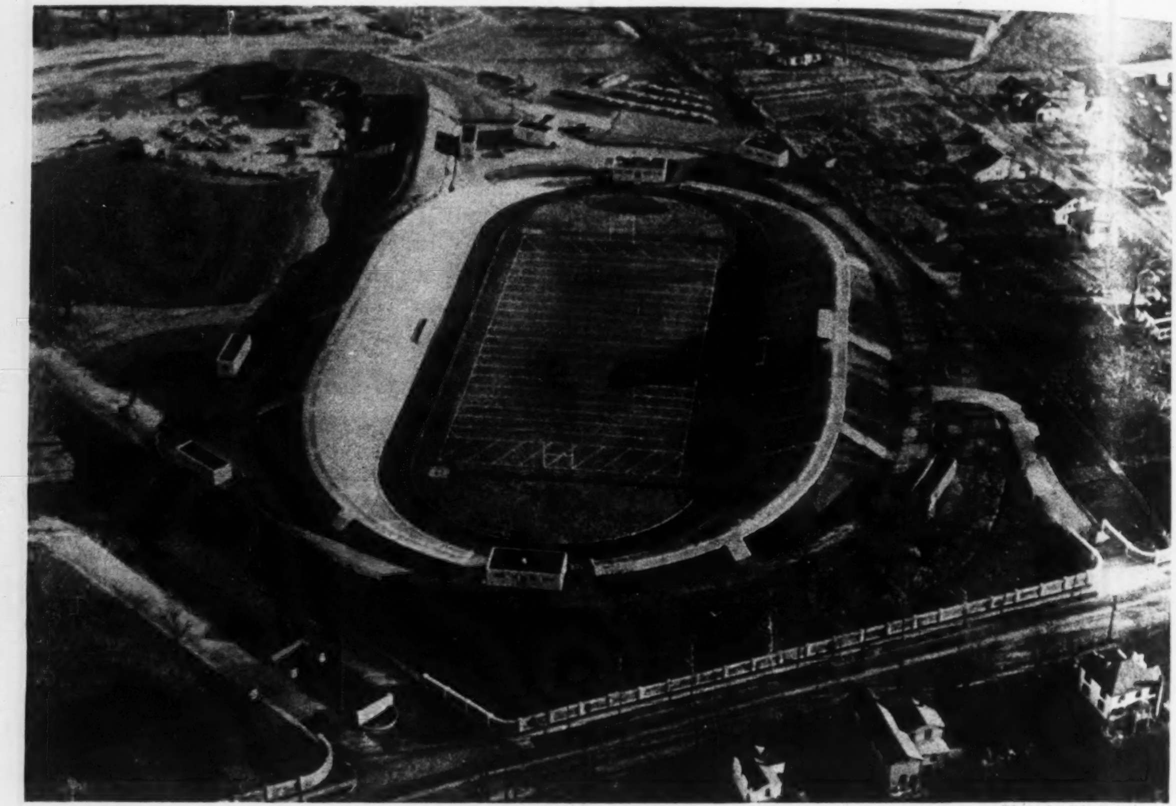


Photo by Edward Chr[illegible]

FIG. I. FOOTBALL STADIUM AND BASEBALL GRANDSTAND AT LYNCHBURG, VA.

Soil Tests Control Stadium Fill

GAVIN HADDEN

Civil Engineer, New York, N. Y.

***Contents in Brief**—Economy dictated the use of cut and fill construction for the new stadium at Lynchburg, Va. Fill settlement under the concrete seat banks was guarded against by laboratory soils studies and field tests for density following compaction in no more than 3-in. layers by sheepsfoot rollers. Levels after five months showed negligible settlement.*

SOIL EXPLORATION and the latest embankment compaction processes make the new municipal stadium at Lynchburg, Va., of particular interest among cut and fill structures of this kind. A cut and fill construction was dictated by the topography and soil conditions of the site and the general economy of the method. When a seat deck is built directly on a sloping earth surface its cost per seat may average one-half or one-third the cost of a similar deck built on frame construction, of concrete or steel, above an approximately level site. The novelty of the Lynchburg operation lies in the application of modern earth engineering practices. These are unusual particularly in respect to control of density of fill based on soil tests and to fill compaction in layers by sheepsfoot rollers.

The stadium structures are adequately shown by Figs. 1 and 2. The inside sloping surfaces of the earth in cut and fill, adjacent to the playing fields, approximate in section continuous smooth vertical curves which were determined by the desired sightlines for the spectators. The seat deck of the football stadium is of uniform width, of 26 rows, for a length of 180 ft. on each side of the field, centered on the transverse centerline of the field. Farther from this centerline the front and rear boundaries of the deck converge; the front boundaries and the treads and risers of the seating deck follow in plan the lines of the running track; the rear boundaries are formed by compound curves extending from the width of 26 rows of seats to a width of only 3 rows, thus producing the interesting skyline curve which is familiar in other stadia of the crescent type and following the sound practice of placing the seats where they are in general most desired by the spectators.

A preliminary layout of the design of the proposed structures disclosed that reasonable economy of construction might make it necessary to cut in some areas to a maximum depth of about 13 ft. and to fill (principally in the central tangent sections of the football stadium) to a maximum depth of about 18 ft. These figures were used as the basis for the explorations. Samples of the soil were collected from a number of test holes dotted over the areas of cut and these samples were tested by Prof. Donald M. Burmister in the Columbia University Soil Mechanics Laboratory. The soil was principally a reasonably uniform mixture of reddish clay and yellowish sand.

Compression tests made in the laboratory showed that when properly compacted the soil would safely support the required loads. The compaction tests, made by the standard Proctor method, showed that the maximum density of the soil was obtained with a dry weight of 101.0 lb. per cu.ft., with 23.5 per cent moisture; also, that the practical range of moisture content for compacting the soil was from 18 to 27 per cent, and that within this range the dry weight of the soil compacted was not less than 97.0 lb. per cu.ft.

The specifications for compacting the fills were written on the basis of the above information. A range of moisture of 18 to 26 per cent was permitted, and it was a fortunate coincidence that the natural moisture content of the soil as it came out of the excavations lay within this range. Very little sprinkling therefore was necessary during construction.

A simple ball test was devised in the laboratory for determining the approximately correct moisture content and this was useful for quick and frequent checking of the material during construction. This field test was described in the specifications as follows:

> An approximate guide to the proper moisture content for this soil is the ball test: if it cannot be formed into a ball about 1½ in. in diameter that will not crumble under slight pressure, then it is too dry; if, on the other hand, the ball shows a flattened area of more than about 1 in. in diameter, when dropped on a smooth hard surface from a height of 2 ft., it is too wet.

Tests made of samples of the compacted soil taken from completed portions of the fills, well below the rolled surfaces, showed dry weights of 96.4 and 96.8 lb. per cu.ft. and this gives a satisfactorily close check with the desired result indicated by the laboratory tests—especially when the wide differences between the field methods and the laboratory methods of compacting are considered.

A further field test was made of a typical sample of soil taken from untouched ground somewhat below the original surface and this showed a dry weight of only 86.1 lb. per cu.ft., an indication that the compacted fills had a greater density than the original ground near the surface. This possibility was foreseen and therefore the specifications required that all surfaces of original ground on which structural fills were to be placed should be rolled (after stripping off the topsoil) before any fill was placed upon them.

Fill compaction exacting

The structural fills were required to be compacted by a sheepsfoot roller, and as the characteristics of such rollers as might be obtainable for this work were not known beforehand, the specifications were written so that the number of passes of the roller over each horizontal layer of fill could be determined by calculation from the characteristics of the roller which was to be used. As a basis for calculation a maximum thickness of 10 in. per layer of fill was set, but the thickness actually used in construction was determined by operating conditions.

The characteristics of the roller which was obtained for this work were such that six passes over each 10-in. layer of fill would produce the required coverage and the proper consolidation. When the operations were being laid out at the start of the grading and consolidating work, however, it was found that placing the fill in 10-in. layers would be difficult to manage with the equipment on hand, and that an efficient sequence of operations would require it placed in thinner layers.

Producing consolidation

It was therefore decided to place the fill in layers not more than 3 in. thick (measured loose) and roll each layer with two passes of the sheepsfoot roller. This not only produced the required consolidation and fitted more efficiently the equipment and the desired sequence of operations, but it also helped to insure more uniform and satisfactory results.

Spreading the fill in thinner layers tended to mix the somewhat variable soils as they came from the excavations, sometimes in small pockets or thin strata, far more effectively than would otherwise have been possible. The attainment of uniformity in the fills was of course one of the major objectives, to insure that such settlement as might occur would be as uniform as possible.

The quantity of finished structural fill required for both the football stadium and the baseball stand was estimated to be about 32,300 cu.yd.; in addition there were about 3,900 cu.yd. of so-called "field fill" mak-

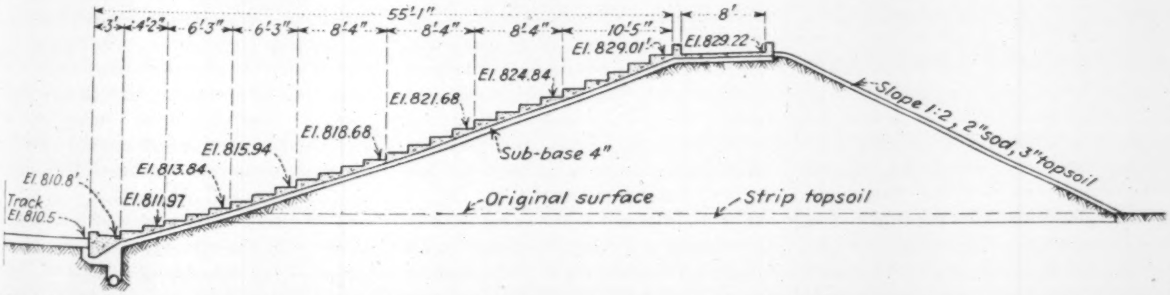


Fig. 2. Transverse section of seat bank at the greath depth of fill indicates the simplicity of the structural elements of the cut and fill stadium constructed at Lynchburg.

ing a total of about 36,200 cu.yd. Although the same careful consolidation was not required for the field fill it was found to be simpler and more efficient to use the same rolling operations throughout. As figured in the field the total came to 36,845 cu.yd. The cost, divided between the WPA and the city of Lynchburg, came to 21c. per cu.yd. of fill (as measured in place, net, after compacting and after trimming).

Levels were taken on July 26 and on Dec. 29, 1939, at 16 different points on the finished concrete, distributed along the passage at the top of the deck on the west fill of the football stadium. At only two points has there been any measurable settlement at all. Both these points are located on a portion of the structural fill—by no means the deepest portion—which was built over a small piece of fill placed shortly before this work was started, and this earlier fill was not built by the methods described. Even at these two points the settlement has been less than ½ in. Elsewhere the levels taken on the two dates are nowhere more than 0.01 ft. apart.

Column footing unique

A portion of the baseball deck is roofed over, and an interesting problem arose in determining the best method of building the foundations for the roof columns, without disturbing the structural fill and without interrupting the continuity of the compacting operations. The columns are located in two rows following the lines of the treads, risers and passage of the baseball seat deck.

All the column footings are 4 ft. below the finished deck surface; this places the rear column footings at one elevation and the forward column footings at another, lower, elevation. Those footings which are in original ground, comprising some of the forward column footings, were excavated and poured after the topsoil had been stripped from their sites and before any of the structural fill had been placed in this part of the work. Those located in structural fill, comprising all of the rear footings and the remainder of the forward footings, were excavated and poured after the structural fill had been completed to the grade of the tops of the footings, and before any fill had been placed above that grade. In pouring the concrete of each footing an anchorage box was built in, to provide for the anchorage of the future column pedestal to the footing. After the setting of the concrete the box forms were removed, a cover was placed over the hole in the concrete, and the building of the structural fill proceeded above the footings as before.

After completion of the structural fill, excavations were made for column pedestals, down to the surface of the footings. In making these small excavations great care was exercised not to disturb the adjacent fill. The anchorage box covers were removed, the concrete surfaces were thoroughly cleaned, the pedestal forms were erected, and the pedestals were then poured, keyed, with reinforcement, into the anchorage boxes. Anchor bolts for the structural steel columns were set in the tops of the pedestals in the regular manner.

Throughout the design and construction of these structures every effort has been made to provide that no appreciable amount of water will ever reach the earth slopes under the seat decks. In addition to the safe insurance against water trouble which is provided by the slag subbase, all expansion joints in the deck are built to reduce leakage through them to a minimum. The longitudinal joints (those parallel with the risers and treads) are built with a sloping overlap which sheds the water down over the surface of the deck; the transverse joints are sealed with rubber expansion joint filler and in addition all the treads are sloped slightly up to these joints so that the drainage on the deck itself tends to flow away from the joints. This deck drainage flows down the deck to the foremost tread where it is collected and led away through a pipe drain. The outside slopes of the fills are covered with topsoil and sod. and the ground outside these slopes is sloped to shed the water everywhere away from the fills.

Directing personnel

The design of the Lynchburg stadium project was a development of the general scheme proposed by Edley Craighill of the City Council. The construction is in charge of Richard F. Wagner, Director of Public Works of the city, and Eldon Rucker is his resident engineer. Close cooperation has been furnished by the WPA, under State Director William A. Smith, Director of Operations Lucien Bass, District Supervisor W. C. Lyle and Area E. C. Supervisor W. Bruce Montgomery. The seating structures and their arenas were designed in the writer's office, with C. A. Holden in charge of the preparation of working drawings and specifications. The writer has served as consulting engineer throughout the work.

Municipal Reports Need Improving

More attractive form and more expeditious publication of municipal reports are recommended by the International City Managers Association as the result of a survey of such reports issued this year. Typical reports for 1938 did not appear until three months after the end of the year, while six weeks is suggested as the limit. Approximately 100 cities made reports to their citizens, as against 81 yast year and 74 in the preceding year. Most cities consider 1,000 copies as a large edition, but the association states that a city of 5,000 population could issue a sufficient number to supply every family for an estimated cost of less than 5c per year person, if the report was limited to about 30 pages and duplicated by some inexpensive reproduction process.

Many of the reports are said to be attractive, well bound, well designed and well illustrated, giving attention to presenting material in terms of municipal functions, policies and problems, rather than of departments or routine activities. Photographs and charts were used more widely than five years ago. And in the financial section, "the traditional lengthy itemization of receipts and disbursements was replaced by concise statements." More than 50 per cent of the reports were 6x9 in., and another 25 per cent were only slightly larger. The average length was 71 pages, although a majority were between 25 and 55 pages.

Bridge Recabled After 12 Years' Service

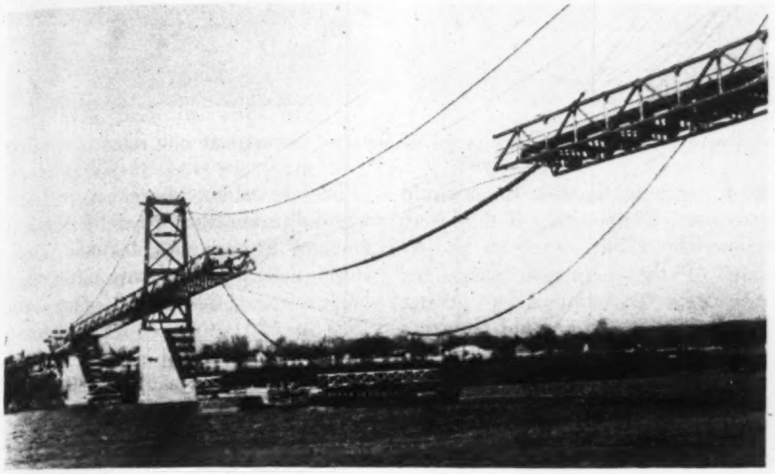
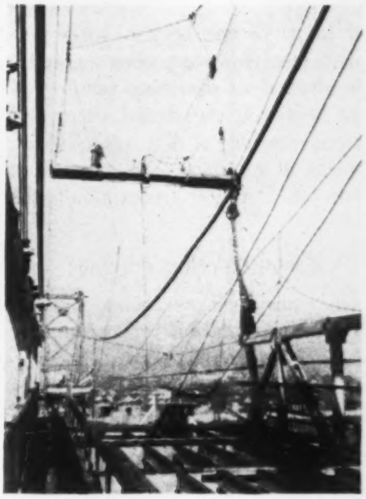


Fig. 1. Two views of Portsmouth bridge during removal of the old cables.



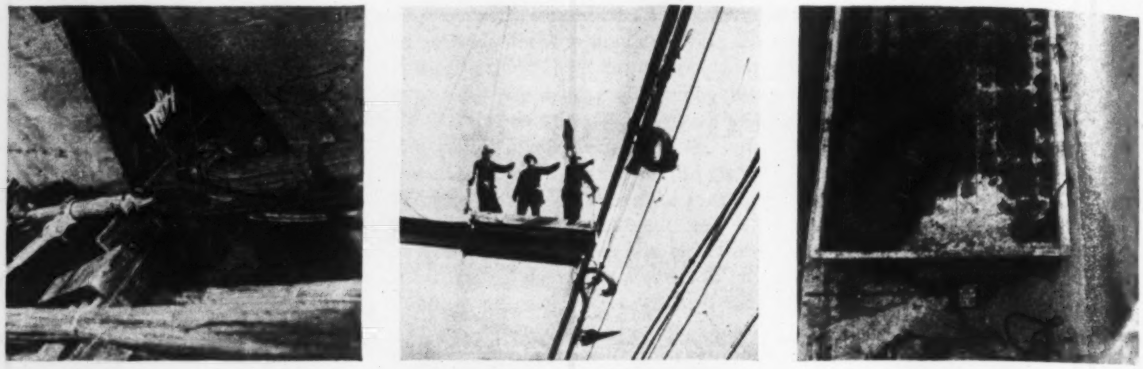
***Contents in Brief**—Wire breaks and rusting in the main cables of the Ohio River highway bridge at Portsmouth necessitated replacement of the cables. To permit of removing the old cables, a section of the suspended structure was taken down and diagonal rope hangers from the tower tops were used to support the remainder. The original cables, consisting of parallel-wire strands of ungalvanized wire, spun on shore, have been replaced by cables made of strands of galvanized wire.*

Broken wires found in the main cables of the General U. S. Grant suspension bridge over the Ohio River at Portsmouth, Ohio, during its annual engineering inspection last May led to immediate closing of the bridge to traffic as a precautionary measure. Detailed examination showed a large number of breaks, most of them at the sides of the strand shoes, and extensive rusting of the cable wires, which were ungalvanized. The Fullerton-Portsmouth Bridge Co., owner, on advice of its consulting engineers, Modjeski & Masters, decided to remove the old cables and replace them by new cables of galvanized strands. This unusual operation, involving noteworthy ingenuity of procedure, has just been successfully completed by the contractor, American Bridge Co.

The bridge, built in 1926–27, is a toll highway bridge of two lanes, with 700-ft. main span, 70-ft. sag, 350-ft. side spans, rocker towers, and stiffening trusses continuous through the towers. The stiffening trusses are 14 ft. deep and have a panel length of 17½ ft. between suspenders. As the only connection between the Ohio and Kentucky banks in a distance of 80 miles, the bridge is an important traffic link.

Reconstruction involved the following steps: (1) Removing the asphalt-on-wood floor to lighten the load on the bridge; (2) cutting apart the stiffening trusses and floor members at chord splices throughout the middle half of the main span (to divide this part of the structure into five 70-ft. sections), and, after releasing these sections from their suspenders, lowering them successively to barges below; (3) removing 8 panels of floor stringers of each side span; (4) supporting the cantilever ends of the main-span trusses by wire rope stays fastened to the tower tops and balanced by similar stays connected to the side spans; (5) unwrapping and cutting the cable strands and lowering them to a barge; (6) extending the anchorage eyebars to anchor plates for the new strand sockets; (7) stringing prestressed strands, 19 for each new cable, by pulling them over the cable bents and tower tops from reels at one end of the bridge; (8) clamping new cable bands in place and attaching the old suspender ropes; (9) hoisting the removed stiffening-truss and floor sections to place and attaching them to the suspenders, and at the same time reconnecting the remaining truss structure to its suspenders; (10) placing the new steel floor grid and re-splicing the suspended structure; (11) placing the concrete roadway surface, and finally (12) wrapping the cables.

Several reconstruction schemes were considered before deciding on the one finally carried out. Before the full extent of the trouble was realized, repair of the cables by splicing new



Figs. 2-4. When the strands of the old cables were cut they coiled back to the diameter of the original wire coils.

end loops to the broken wires was considered. However, when examination showed an alarming number of wire breaks at the strand shoes and serious rusting of the cable wires, thought of repair was abandoned in favor of complete renewal of the cables.

Reconstruction schemes

One proposed recabling method involved installation of temporary cables to carry the suspended structure during removal of the old cables and construction of new ones. Another was based on supporting the suspended structure temporarily by bents placed under main and side spans. The former scheme was rejected because of its high cost, the second because of cost and risks, in view of the fact that temporary bents under the main span might be endangered by ice. Further study led to the diagonal hanger plan, whose general arrangement is sketched in Fig. 5. It should be noted that the towers are of rocker type and required to be braced or stayed before the cables could be removed.

Calculation showed that by utilizing the full bending strength of the stiffening trusses in the side spans and at the towers in conjunction with a set of diagonal rope hangers from the tower tops, the side spans could be made self-supporting if they were relieved by 175-ft. cantilever projections of the main-span suspended structure. To support a greater length of main span would require a very extensive and costly system of stays, amounting to a set of temporary main cables. It was found cheaper to remove the middle half of the main span by cutting it into sections and lowering it section by section to barges directly below, from which it could again be hoisted to place when the new cables were in position.

As this scheme cost much less than either of the other plans and involved less risk, it was adopted and carried out without change.

Two important auxiliary operations were: (1) extending the anchorage eyebar system from the existing 6-eyebar chain (for the three strands of each cable) with bars laid flat, to a new 6-eyebar chain with bars set vertical, extending from the old strand-shoe pins to new anchor plates placed sufficiently far out of the anchorage wells to bring the anchor plates above probable extreme flood stage; and (2) installing a new steel and concrete floor in place of the asphalt-on-wood floor of the old bridge.

The old cables, whose construction was fully described by D. B. Steinman, of Robinson & Steinman, consulting engineers, shortly after the bridge was built (*ENR*, Oct. 20, 1927, p. 620), were $7\frac{1}{8}$ in. in diameter under the wrapping, each comprising 1,458 wires of No. 8 gage, total section 30.05 sq. in., in three parallel-wire strands laid up on shore. The new cables consist each of 19 shop-fabricated prestressed strands, of which 13 are $1\frac{3}{4}$ in. in diameter and six $1\frac{1}{4}$ in. in diameter (Fig. 6); the diameter of each of the new cables is $7\frac{13}{16}$ in. and its sectional area 31.40 sq. in.

Dismantling begun in October

A short time after discovery of the wire breaks, late last May, the asphalt-covered wood floor of the bridge (originally 2 in. and later 4 in. of asphalt on 6-in. laminated redwood flooring) was removed, lightening the dead load by nearly half, in order to forestall further wire breakage. Thereafter four months were consumed in studying reconstruction plans and reorganizing the company's financial structure to provide for the cost of the reconstruction. Dismantling was begun Oct. 15, 1939, with removal of floor stringers; disconnecting the trusses and floor at

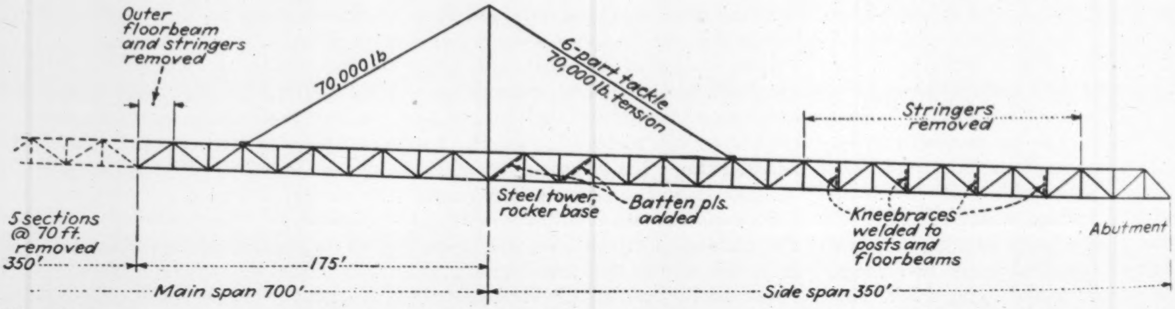

Outer floorbeam and stringers removed
70,000 lb
6-part tackle 70,000 lb. tension
Stringers removed
Steel tower, rocker base
Batten pls. added
Kneebraces welded to posts and floorbeams
Abutment
5 sections @ 70 ft. removed
350'
175'
Main span 700'
Side span 350'

Fig. 5. Temporary hanger used to support the 175-ft. projection of the suspended structure during cable replacement.

alternate splices throughout the middle half of the main span followed. To prevent the development of excessive bending moments in the stiffening trusses when the floor load was removed, the horizontally sliding truss supports at the towers were cut loose, permitting the trusses to rise 5 in. They were reconnected to the tower reaction girders before the suspenders were removed.

Hitch plates bolted to the top chords of the stiffening trusses three panels back from the ends of the cantilevers were now connected by six-part tackle of ¾-in. wire rope to slings fastened around the tower tops, and similar hanger connections were placed in the side spans. These diagonal hangers were pulled by hand winches to 70,000 lb. tension, the amount computed as the necessary pull to limit the truss stresses to a safe figure. The hangers served to brace the towers as well as support the trusses. The five sections of the middle 350-ft. length of the suspended structure were next lowered successively to the river, and the barges carrying them were moored along the banks, in storage for reerection.

Provision for erection stresses was made by welding diagonal braces between certain of the truss posts and floorbeams to give lateral support to those unbraced top chords of the trusses which would be in high compression after removal of the cable support. Also, the compression diagonals of the trusses were reinforced at points of heavy temporary shear near the towers by welding in additional batten plates. Highlines were strung across the tower tops to carry a traveling platform for work on main span suspenders and cables, and a simple two-rope footbridge was swung between the cantilever ends of the main-span structure to carry the men from one half of the job to the other. Conduits which crossed the bridge were supported across the gap by ropes.

Replacement of cables

The wrapping wire of the cables having been removed, dismantling of the first strand was taken in hand by attaching 3-ply tackle at two points at mid-span so that the blocks were about 8 ft. apart, with lead line running to the hoisting engine at one tower. The tackle was stressed enough to take the strand tension, and the strand was then burned between the blocks. Next the tackle was slacked off, the blocks being supported by loops passed over the remaining strands. In the meantime the side-span segments of the strand were similarly slacked back by tackle attached near the cable bent, the strand being cut between the tackle blocks. When the sag of the strand reached the deck of the cable barge below, the cut end was lowered to the barge and then the strand burned through at the tower.

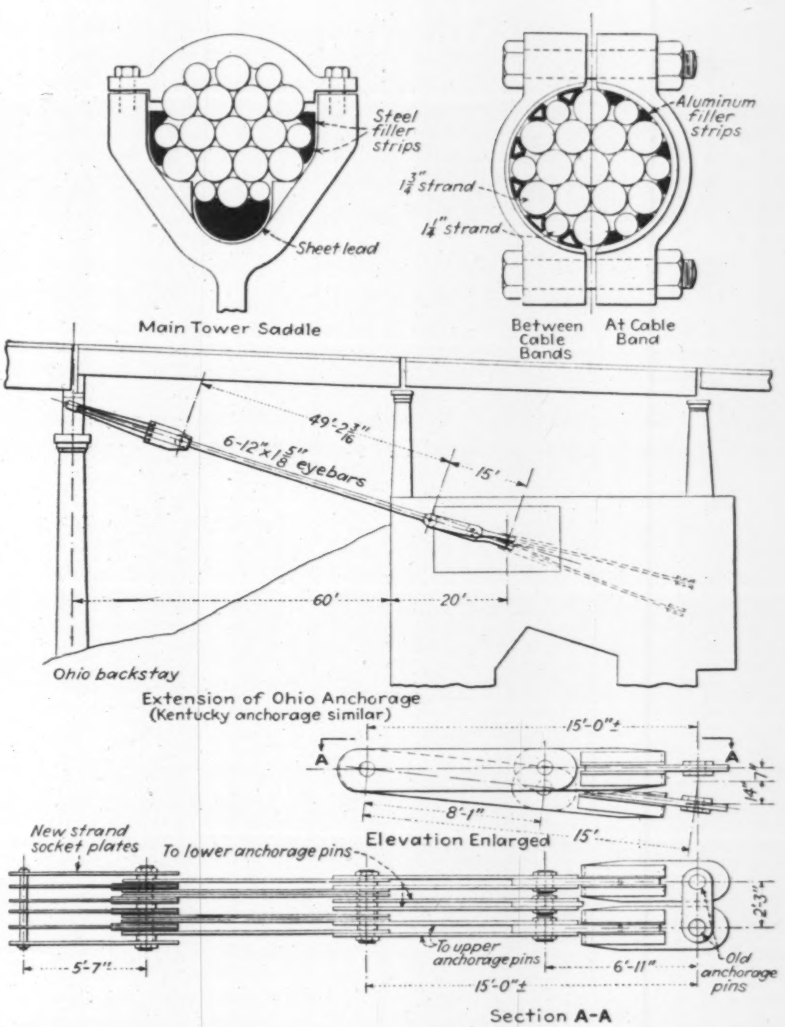


Fig. 6. New cable sections, and extension of anchorage which was constructed to receive new strand sockets.

A different method was required for taking down the last strand of each cable. The operation was limited by the amount of cable available on the hoisting engine drum, each of which carried 1,100 ft. of ¾-in, rope, and as both drums of each tower engine were in use during the operation it was not possible to splice the one rope to the other. With a strand tension of about 34,000 lb. and an allowable working stress of 15,000 lb. in the ¾-in. rope, 3-ply tackle was required to hold the strand before it could be burned through. But 1,100 ft. of rope was not sufficient to slack off far enough for bringing the strand down to the barge. Accordingly, when the tackle had been extended enough to bring the remaining tension down to the capacity of a single line, the burned ends of the two segments were connected by a single rope, the 3-ply tackle was unreeved and its rope was used as a single line from the end of one strand segments to the opposite tower top and thence down to the hoisting engine. A line from the other hoisting engine was similarly attached to the opposite strand. After removal of the tie line it was now possible to lower one strand segment to the barge by slacking off the hoist line.

In order to clear the channel for shipping, this strand was burned off at barge height at the tower, and then the opposite strand segment lowered to the barge in the same way. The remaining parts of the strand offered no difficulty in removal.

Placing the new strands was done by hauling them over temporary sheaves at cable bents and tower tops from reels at the Kentucky anchorage, by a hauling line extending across the river to a hoisting engine on the Ohio side. When the middle strand of the bottom layer was connected to the new anchor plates it was adjusted to proper sag by pulling it through the saddles with a chain hoist and adjusting the backstays by hand winch, after which shim plates were inserted back of the socket pin bearings to fix its position permanently. The other strands were adjusted to the first one. The saddle seats, shaped to fit the old 3-strand cables, were adapted to the new cables by steel filler strips of suitable shape.

When the cables were completed, new cable bands were attached and the old suspender ropes were hung from these. The truss sections were then hoisted to position from the barges on which they had been stored and connected to the suspenders.

In this bridge the original design provided no adjustment at the connection of suspenders to floorbeams. No change was made in this detail in the reconstruction. Care was necessary in reconnecting the suspenders to the removed truss sections and to that part of the superstructure left in place in main and side spans, to avoid undue concentration of load on the cables.

Last operations in the reconstruction were laying the new steel grid floor, filling the grid with concrete, resplicing the trusses, applying hollow aluminum fillers in the spaces between the outer strands (similar fillers, but solid, had been placed under the cable bands when the bands were attached to the cables), and wrapping the cables with soft galvanized wire.

Reconstruction at present is practically complete, and reopening is expected by May 15. The entire work will cost about $275,000 against an original cost of about $1,250,000 for the complete bridge.

Breaks and rust in old cables

As already stated, the first wire break was discovered in the course of annual engineering inspection of the bridge on May 20, 1939. At that time the bridge had been in service a little over 12 years. The inspecting engineer, when examining the Ohio anchorage end of the upstream cable, noted a bulge in the asphalt coating which had been placed on the exposed wires between splay casting and strand shoes for rust protection some years ago. On prying off the coating here, he found a loose wire. The wire was broken at the side of the strand shoe. Further examination showed other breaks and much rusting of the wires, and the bridge was closed pending thorough examination.

More complete examination of conditions at the strand shoes, and inspection of the interior of the cables at various points of all spans and backstays by removing short sections of wrapping wire and prying the cable wires apart by wooden wedges, showed many more breaks at the strand shoes and the presence of rust in the interior of the cable. No breaks outside of the anchorage were discovered before the cable was unwrapped at a much later date. The outer inch or so of the cable, directly under the wrapping, appeared to be in fair condition, but the interior was cemented together by dried paint and rust.

Within a few days after the first discovery, watchers placed in the anchorage pits to detect any snapping of wire, especially in the quiet night hours, reported that additional breaks had occurred. The floor was therefore removed to lighten the load on the cables, as it was believed necessary to keep the bridge out of service until the cables could be repaired or replaced.

The record of breaks compiled after the seizings were removed from the cable strands at the strand shoes is given in diagram form by Fig. 7. The Ohio end of the upstream cable showed 198 breaks, the Kentucky end of the same cable 110 breaks; at both ends the count covers only five of the six half-strands, as the seizings were not removed from the sixth half-strand because of the large number of breaks in the other half-strand. The condition revealed by this examination led to the decision to replace the cables by new ones. Later, when the cables were taken down, wire breaks were found also at other points, though some of these may have been caused by the removal operations.

As shown by Fig. 7, the upstream cable had the most breaks. This cable carried a slightly heavier load than the other, as the bridge footwalk was on the downstream side and therefore the vehicle roadway center was upstream of the centerline.

Some facts about the old cables are pertinent in this connection. They were made of No. 8 wire (0.162 in.

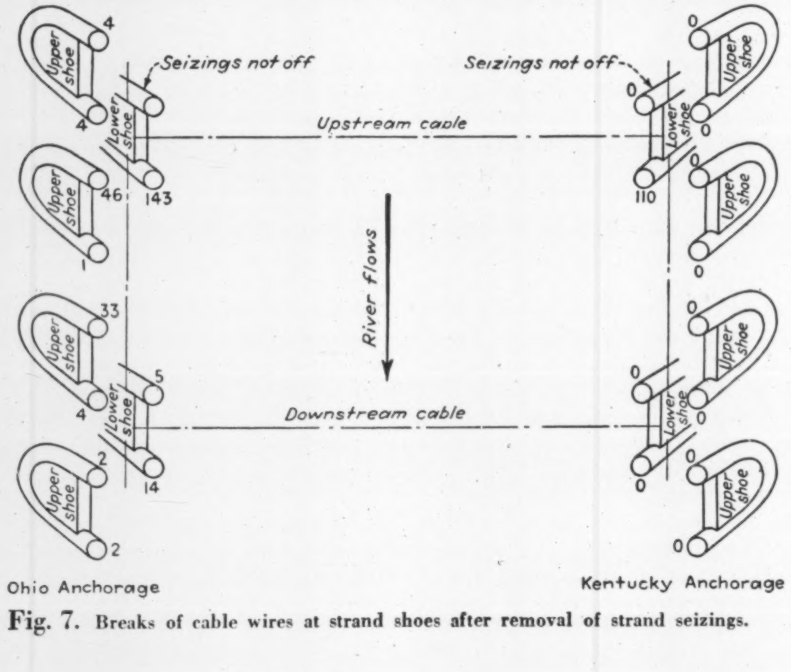


Fig. 7. Breaks of cable wires at strand shoes after removal of strand seizings.

diameter), ungalvanized, drawn from open-hearth wirebars, to specified minimum tensile strength of 220,000 lb. per sq. in. The choice of ungalvanized wire was based on the excellent performance of such wire in the cables of the Williamsburg bridge for more than 20 years, as stated in the article on the construction of the Portsmouth bridge previously referred to. No. 8 wire has been used extensively in Ohio River suspension bridge practice, while elsewhere No. 6 wire (0.194) in. has generally been used.

Following Ohio River bridge practice, also, the cables were not spun in place but were laid up on shore, each in three strands of 486 wires, and thoroughly covered and impregnated with red lead paint. The individual strands, with their strand shoes attached, were then pulled across the river, connected to the anchorage bars, and hoisted to place.

The first strand laid up on shore, when completed and released from its temporary anchorages, coiled or spiraled seriously, but was successfully straightened out. This was not the strand in which broken wires were first discovered, and proved to be one of the best strands of the two cables in respect to freedom from breaks.

At the anchorages, the moist atmosphere in the wells led to application of a protective coating to the exposed wires here, soon after the bridge was completed. Later, in the unprecedentedly high floods of January, 1937, and February, 1939, flood waters entered the Ohio anchorage wells. When the floods went down the wells were drained, hosed out, and dried by stoves placed in them, after removing some of the asphalt coating of the cables to allow any water between wires to drain out. Flood water did not enter the Kentucky anchorage at any time, as it is 20 ft. above the Ohio anchorage.

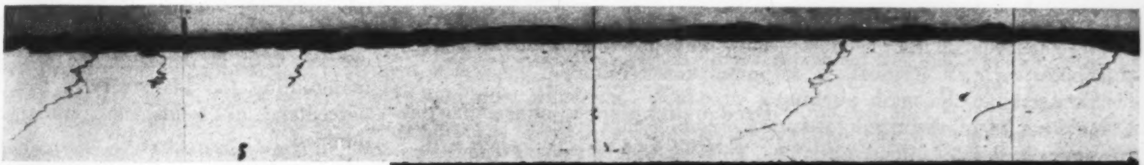
As part of the examination of the bridge after discovery of the wire breaks, about 100 broken and unbroken wire specimens were subjected to strength tests and microscopic examination at the Carnegie Institute of Technology. All specimens were found to have roughly the same curvature as the coils in which the wire originally came from the wire mills to the bridge site; 68 specimens measured for curvature showed diameters of 20 to 34 in. All samples from the Ohio anchorages were reported to be badly rusted and pitted, those from the Kentucky anchorages and the outer parts of the main cable only slightly rusted, while specimens from the interior of the main span showed bad pitting.

Tensile tests of specimens distant from field breaks showed the breaking strength to range from 242,000 to 265,000 lb. per sq. in. (specified minimum strength was 220,000). Specimens taken as close as possible to field breaks showed a strength range from 132,000 to 261,000. The stress corresponding to 0.7 per cent elongation (the specified yield strength, fixed at 140,000 lb. minimum) ranged from 167,000 to 185,000 lb. per sq. in.; elongation in 10 in. from 0.5 to 1.7 per cent; reduction in area from 19.3 to 47.0 per cent in specimens distant from field breaks, and 6.0 to 37.0 per cent in specimens close to field breaks.

All specimens with tensile strength under 220,000 lb. showed evidence of cracks in the tensile fractures, the laboratory reported. Micrographic examination of longitudinal sections close to field breaks showed cracks as reproduced for one specimen in the micrographs Fig. 8. Some of the transverse sections also showed radial cracks, apparently longitudinal.

Reporting on its examination of 75 test specimens, the laboratory stated: "Only those at the anchorage shoes seemed dangerously brittle. At these locations the wire appears to have been subjected to a combination of stress and corrosion resulting in stress-corrosion cracks. Specimens from other locations in spite of corrosion seem as yet to have suffered no important deterioration in mechanical properties; these latter tests have not been extensive."

Substantially complete elasticity of the wire is evidenced by the return to original coil curvature after 12 years under stress in straight condition. This elasticity also appears from Figs. 2 to 4, which show cut or removed strands.



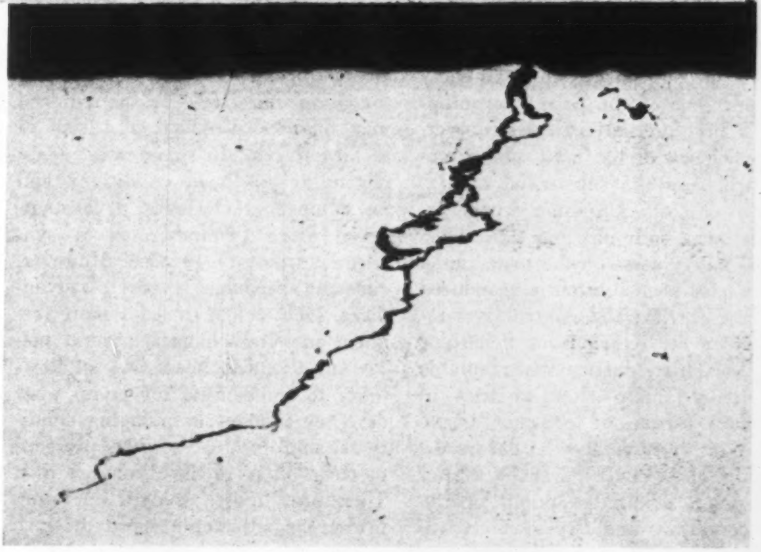


Fig. 8. **Under the microscope, sections of the wire near breaks showed numerous cracks. The longer picture above shows a longitudinal section through the outer part of a short piece of wire at 25 magnification, while the other picture shows one of the cracks in this piece at 100 magnification.**

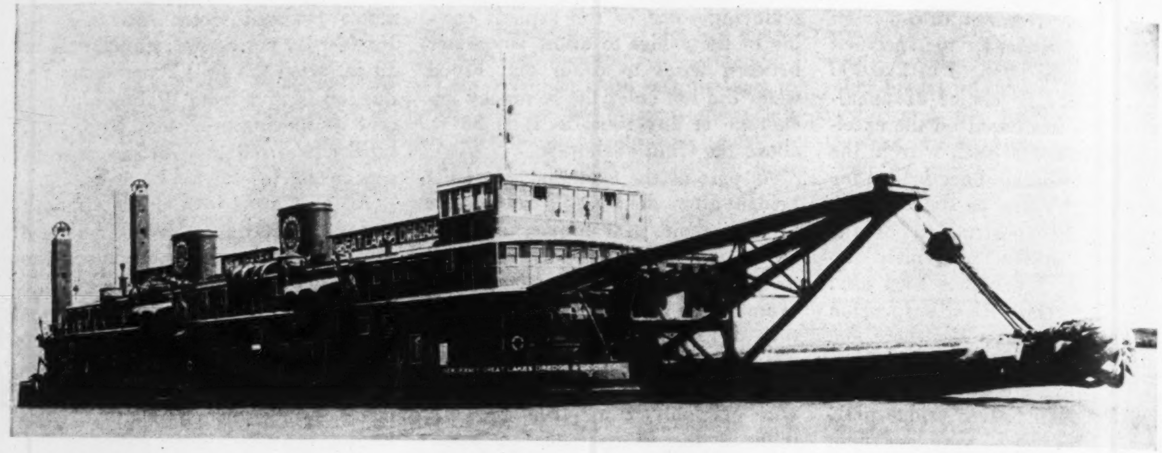


FIG. I. DIESEL-ELECTRIC DREDGE "NEW JERSEY" HAS ADJUSTABLE SPEED CONTROL FOR EFFICIENT OPERATION.

Reducing Hydraulic Dredge Operation Cost

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Schenectady, N. Y.

***Contents in Brief**—Considerable savings in electric power costs on hydraulic dredges can be effected through use of a proper speed control system for the main pump drive. Two such systems, the Kraemer and Scherbius, which have been successfully applied to both old and new dredges, are described here. They economically meet dredge pump requirements of constant torque or constant horsepower at variable speeds and have further reduced operating costs by increasing the daily yardage.*

About 75 per cent of the installed horsepower in a typical hydraulic dredge is in the main pump drive, but because of sustained load on the pump and intermittent operation of other power-operated equipment on board, operation of the pump accounts for approximately 80 per cent of the power consumption. Therefore, any increase in overall efficiency of the main pump motor will result in substantial savings in power costs. On some dredge installations, both old and new, electrical power costs on the main pump drive have been substantially reduced by use of electrical control systems of either the Kraemer or Scherbius type, which are particularly adaptable to dredge pump characteristics of constant torque or constant horsepower at variable speeds. Before describing these control systems, a brief discussion of dredge pump operating conditions and requirements will show why power control can reduce power consumption.

Dredge pump speed characteristics

To meet widely varying conditions of hydraulic head, the main pump drive is usually adjustable in speed. Depending on the range in head and the pump characteristics, the required maximum speed reduction is from 20 to 50 per cent. In some cases, again depending on head conditions and on pump characteristics, a constant-speed drive (wound rotor or synchronous motor) is used. However, constant speed has several disadvantages, such as lost time for more frequent impeller changes to meet major variations in head, lack of flexibility to compensate for pump wear or other changes in pumping conditions, and lack of reserve pressure to clear plugs in the discharge line. Therefore, most dredge operators prefer the adjustable speed drive.

The characteristics and method of operation of the centrifugal dredge pump require reduced speed operation to be at constant torque, or, infrequently, at constant horsepower. As the head is decreased, the pump speed is reduced to maintain substantially constant power input to the motor, preventing excessive overloading. Likewise, the speed is increased with increases in the head, maintaining the load, rate of flow, percentage of solids, and yardage pumped.

Induction motor drives

On dredges obtaining alternating current for power through a cable from shore, the main pump is usually driven by a heavy-duty, wound rotor type induction motor, with an adjustable secondary resistor or a liquid rheostat to control the speed over the specified range. Such a drive is simple, reliable, and well suited to meet the requirements. After the motor has been connected to the power line, the operator can bring the pump up to required speed by moving the master switch or drum switch. When the motor input is held constant, as indicated by a line ammeter, speed reduction is inherently at constant torque and shaft horsepower output is directly proportional to speed.

However, the "slip energy" or power lost in the resistor, is proportional to speed reduction; the difference between shaft or useful horsepower output, and equivalent top speed horsepower output at the same torque is dissipated as heat in the resistor. At 15 per cent speed reduction, 85 per cent of the motor output is put into the pump, and 15 per cent is wasted in the resistor, and at 30 per cent speed reduction, 70 per cent of the output is utilized and 30 per cent wasted. The power losses in the motor itself are more or less fixed by design limitations, but elimination of these resistor losses offers interesting possibilities in materially reducing the total dredge power costs, not only on new dredges, but also on existing units where the main pump motor is already installed. Control systems of the Kraemer or Scherbius type have been successfully applied to dredge pump drives and eliminate a large part of the resistor losses. These drives are well liked by the operators and their use has resulted in marked savings, according to the owners.

Control systems

The basic advantage of the Kraemer and Scherbius control systems is that the main motor slip energy, instead of being dissipated as heat in the resistor, is salvaged, and, less the auxiliary machine losses, is returned to the line as useful electrical energy (constant-torque arrangement), or to the main motor shaft as useful mechanical energy (constant-horsepower arrangement). A schematic diagram of the Kraemer system constant-torque arrangement is shown in Fig. 2. After the main motor and the motor-generator set are brought up to speed on the starting control, the main motor slip-ring connections are transferred to the alternating current end of a synchronous converter. The direct current end of the converter is connected to the d.c. motor of the motor-generator set. When the d.c. motor field is energized, a d.c. voltage is built up across the converter and an a.c. voltage, at slip frequency, is applied to the rings of the main motor, causing it to slow down. Speed is controlled by the degree to which the field of the d.c. motor is applied, and a master switch controlling the motor field rheostat gives the operator complete control of main motor speed over the operating speed range.

The converter runs at slip frequency with its speed proportional to the main motor slip or speed reduction, and converts the slip energy to direct current which drives the motor-generator set and feeds the slip energy back into the line, the squirrel-cage motor acting as an induction generator. This may be a synchronous motor if desired.

Fig. 3 shows a Kraemer system in a constant horsepower arrangement with the salvaged slip energy returned to the main motor shaft, so that substantially full rated horsepower is available over the specified speed range. Under some conditions the constant horsepower arrangement, designed for constant torque operation, may reduce the initial cost.

These systems have the following operating advantages and characteristics: (1) approximately 85 per cent of the slip energy is saved; (2) the lagging reactive kva to the main motor is largely supplied by the synchronous converter so that the power factor of the main motor is improved to 95 per cent or better, and the power factor of the dredge to approximately 90 per cent or higher; and (3) for a given setting of the master switch speed selector, main motor speed is substantially constant over a wide range of torque loads.

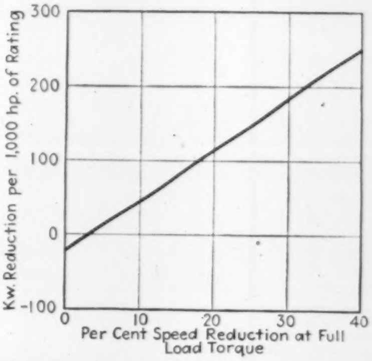


Fig. 5. Approximate reduction in kilowatt input to main motor for Kraemer constant-torque control in place of resistor control.

Approximate power savings for a Kraemer constant torque system at various speeds are shown in Fig. 5, but this curve does not indicate the further savings in the power bill or those through reduced size of cable and transformers sometimes made possible by the improved power factor.

In the similar Scherbius system, the functions of the synchronous converter and the d.c. motor are combined in one rotating regulating machine to convert the slip energy di-

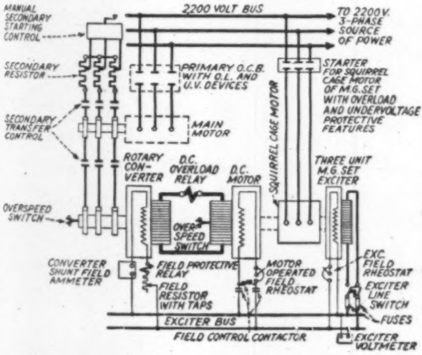

MANUAL SECONDARY STARTING CONTROL
2200 VOLT BUS
TO 2200 V. 3-PHASE SOURCE OF POWER
SECONDARY RESISTOR
PRIMARY O.C.B. WITH O.L. AND U.V. DEVICES
STARTER FOR SQUIRREL CAGE MOTOR OF M.G. SET WITH OVERLOAD AND UNDERVOLTAGE PROTECTIVE FEATURES
SECONDARY TRANSFER CONTROL
MAIN MOTOR
SQUIRREL CAGE MOTOR
ROTARY CONVERTER
D.C. OVERLOAD RELAY
D.C. MOTOR
THREE UNIT M.G. SET EXCITER
OVERSPEED SWITCH
OVER SPEED SWITCH
CONVERTER SHUNT FIELD AMMETER
FIELD PROTECTIVE RELAY
FIELD RESISTOR WITH TAPS
MOTOR OPERATED FIELD RHEOSTAT
EXC. FIELD RHEOSTAT
EXCITER LINE SWITCH
FUSES
EXCITER BUS
FIELD CONTROL CONTACTOR
EXCITER VOLTMETER

Fig. 2. Wiring diagram for Kraemer constant-torque control system. A master switch gives the operator complete speed control over operation range.

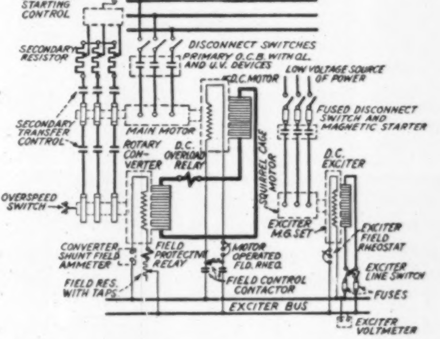

MANUAL SECONDARY STARTING CONTROL
HIGH VOLTAGE SOURCE OF POWER
SECONDARY RESISTOR
DISCONNECT SWITCHES
PRIMARY O.C.B. WITH O.L. AND U.V. DEVICES
D.C. MOTOR
LOW VOLTAGE SOURCE OF POWER
FUSED DISCONNECT SWITCH AND MAGNETIC STARTER
SECONDARY TRANSFER CONTROL
MAIN MOTOR
ROTARY CONVERTER
D.C. OVERLOAD RELAY
SQUIRREL CAGE MOTOR
D.C. EXCITER
OVERSPEED SWITCH
EXCITER M.G. SET
EXCITER FIELD RHEOSTAT
CONVERTER SHUNT FIELD AMMETER
FIELD PROTECTIVE RELAY
MOTOR OPERATED FLD. RHEO.
EXCITER LINE SWITCH
FIELD RES. WITH TAPS
FIELD CONTROL CONTACTOR
FUSES
EXCITER BUS
EXCITER VOLTMETER

Fig. 3. Diagram of Kraemer constant-horsepower control system. Salvaged slip energy is returned to the main motor shaft.

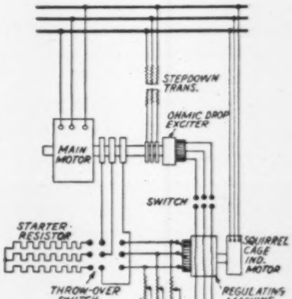

STEPDOWN TRANS.
OHMIC DROP EXCITER
MAIN MOTOR
SWITCH
STARTER RESISTOR
SQUIRREL CAGE IND. MOTOR
THROW-OVER SWITCH
REGULATING MACHINE
FIELD CONTROL TRANS. FOR SPEED ADJUSTMENT

Fig. 4. Layout of a double-range Scherbius drive, which permits speed regulation both above and below synchronous speed of the main motor.

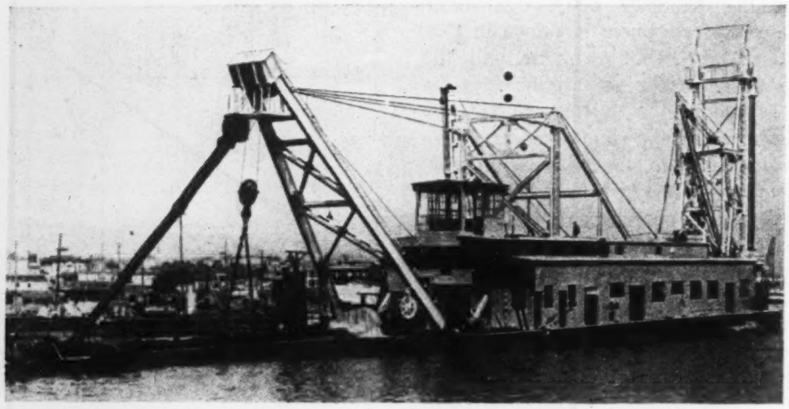


Fig. 6. **The speed control systems are applicable to old as well as new dredges. The Scherbius system was applied to the 24-in. dredge "Marshall C. Harris" with highly satisfactory results.**

rectly to mechanical energy. Somewhat special control and excitation equipment are required in this system, and the power factor correction is not as uniform. When costs and other factors are comparable, the Kraemer system will usually be preferred. However, the Scherbius system has one advantage in the ability, lacking in the Kraemer system, to carry the fully loaded main motor through synchronous speed, and run it above as well as below synchronism (Fig. 4). This is known as a double-range Scherbius as distinguished from a single-range Scherbius or Kraemer, which can only reduce the motor speed.

In the double-range constant-torque system the synchronous speed, and rating of the main motor are reduced to some intermediate value in the specified pump speed range. For example, if the pump takes 2,800 hp at 400 rpm with 30 per cent speed reduction specified, a 2,500-hp 360-rpm motor might be selected. At speeds below 360 rpm, slip energy would be salvaged as in the case of the Kraemer drive. At speeds above 360 rpm the necessary additional power would be taken from the line through the Scherbius set and fed into the main motor through the slip rings to develop the higher horsepower at higher speeds. This system may be particularly desirable where the main motor is already installed and—pump, motor design and space limitations permitting—it is desired to increase the pumping head by increasing the pump speed above the existing top speed. In the Scherbius system, as in the Kraemer, a master switch gives the operator control of speed, and the arrangement can be for constant torque or for constant horsepower.

Comparative power savings

An indication of the possible savings in power costs through use of the control systems is given in the accompanying tables. An approximate comparison on motor operating characteristics is shown in Table I, worked out on a specific project requiring a 2,000-hp motor with 36 per cent speed reduction at full-load torque.

The power cost reductions shown in Table II are based on a case where a 2,500-hp Kraemer drive was arranged for 25 per cent speed reductions at full-load torque. The additional cost of the Kraemer control over resistor or liquid rheostat control, exclusive of installation, was from $30,000 to $35,000, depending on the exact arrangement, line voltage, etc. The table, based on assumed actual digging time of 20 hours per day, 300 days per year, or a total of 6,000 operating hours per year, shows approximate annual power savings, and the per cent of gross return on an original investment of $35,000. Savings from power factor improvement are not included. This might be considered as offsetting installation and maintenance charges. The figures may be adjusted in direct proportion for other power rates, total hours digging per year or average speed reduction. The net power savings in any particular case will depend on such factors as ratio of time of actual operation, power rate, power factor bonus and penalty clauses in the power contract and the average and maximum speed reduction, but the results in Table II are typical of what may be expected.

Reduction in power cost may not be the only savings effected by the variable speed control. For example, adjustable speed operation will eliminate some of the impeller changes, necessary to match the hydraulic head, required with constant-speed control, thus saving shut-down time. Again, if constant-horsepower adjustable speed control is selected, substantially full horsepower will be available at all speeds, which means that with line and pump conditions permitting, higher speed operation is possible under low heads, increasing the yardage pumped without serious overloading. Also, as operation at reduced speed is economical with the Kraemer or Scherbius control system, a drive may be selected that will run normally "under wraps" at 10 to 15 per cent reduction in speed, leav-

TABLE I—MOTOR OPERATING CHARACTERISTICS

With Different Controls

Type of Control	At Maximum Speed Hp	Rpm	Eff.	P.F.	At Minimum Speed Hp	Rpm	Eff.	P.F.
Resistor	2,000	355	94.0	81.5	1,250	225	58.5	81.5
Scherbius *	2,000	360	90.5	93.0	1,250	225	86.5	89.0
Kraemer †	2,000	350	91.5	99.0	1,250	225	83.5	99.0

Note: * Double-range. Scherbius set transfers from starting to regulating at approx. 296 rpm. If run non-regulating (auxiliaries shut down, motor rings shorted) it develops approx. 1,670 hp at 296 rpm.

† Single-range. Kraemer set transfers from starting to regulating at approx. 355 rpm. If run non-regulating, rings shorted, it is same as motor with resistor control, and develops 2,000 hp. at 355 rpm.

TABLE II—ANNUAL POWER SAVINGS

With Kraemer, $35,000 Control System

Power Rate Per Kwh	Aver. 10 Per Cent Speed Reduction Amount	Ret. on Invest. Per Cent	Aver. 15 Per Cent Speed Reduction Amount	Ret. on Invest. Per Cent	Aver. 20 Per Cent Speed Reduction Amount	Ret. on Invest. Per Cent
$0.006	$5,700	16.3	$8,500	24.5	$11,400	32.6
0.007	6,650	19.0	10,000	28.6	13,300	38.0
0.008	7,600	21.7	11,400	32.6	15,200	43.4
0.009	8,550	24.4	12,850	36.7	17,100	48.8
0.01	9,500	27.1	14,300	40.8	19,000	54.3

ing a reserve speed for building up pressure to clear a plugged or sanded line without shutting down. It is not possible to build up a reserve pressure for clearing the line with constant-speed control. Furthermore, available reserve speed will enable the operator to crowd the cutter head harder when desired to increase the yardage pumped.

Typical installations

The 24-in. West Coast dredge *Marshall C. Harris* was equipped in 1932 with a double-range constant-torque Scherbius system rated at 2,800/2,500/1,950 hp, at 400/360/280 rpm, respectively. At that time it was estimated that the additional investment would be written off in less than three years; actually, the results have been better than expected. It is reported that the power cost per yard of material pumped has been less on this unit than on any other hydraulic dredge operating in the vicinity. Furthermore, because of the ease of operation and time saved by eliminating impeller changes when changing from one length of pipeline to another, the *Marshall C. Harris* now pumps more material in a given time than any other dredge formerly operated by the owner.

A 28-in. dredge equipped with a wound-rotor induction-type main motor and starting control, was changed over to constant-torque Kraemer control in 1935. The savings in power, in time, and through increased yardage pumped are reported to have been of such magnitude as to write off the additional investment in less than one year.

Self-powered dredges

In steam-turbine-driven dredges the mechanical drive as geared to the main pump offers a convenient and economical means of speed reduction, and electric main pump drive in such cases would not ordinarily be considered. However, in all-electric steam dredge, the Kraemer or Scherbius system of control for the main pump motor would result in fuel savings similar to the savings for dredges operated by an outside source of power.

For a dredge powered by diesel engines, all-electric operation offers several advantages, such as more flexibility of speed control or for shutdown of the main pump, selection of engine ratings and speeds, location of engines independent of pump requirements, and operation of engines at their most desirable speed, independent of pump speed. With all-electric drive on such a dredge, maximum operating efficiency at minimum cost will result from the use of direct current generators and motors. With this arrangement, speed adjustment of the main drive motor and other adjustable speed motors can be by means of field control, largely eliminating resistor losses except while starting. The 30-in. diesel electric dredge, *New Jersey* (Fig. 1), is so arranged.

Several other systems of speed control that eliminate resistor losses are known, but the Kraemer and Scherbius systems have proven unusually satisfactory for dredge pump applications.

Free Lot Surveys Made In Fort Dodge, Iowa

J. L. Parsons
City Engineer, Fort Dodge, Iowa

Contents in Brief—Fort Dodge has changed its lot surveying situation from chaos to order by monumenting all blocks and by making plats of the individual blocks. As a result, the city has been able to abolish a $3 fee for lot re-survey service.

A CITY-WIDE CHECK SURVEY of subdivisions and block corners has created an efficient control system which enables the city of Fort Dodge, Iowa, to make lot re-surveys as a free service to property owners.

Before 1935, when the author became city engineer of this Iowa county seat city of 22,000, the engineering department had made resurveys of lots at $3 apiece. Three factors made this procedure unsatisfactory. First, there was not an adequate system of control monuments at block corners. Second, records of re-surveys that had been made were incomplete and, third, the charge for the service, small as it was, discouraged its use and encouraged property owners who desired corners to rely upon a system of guesswork which was only a little worse than that which the city was forced to use.

This lack of adequate control, records and surveys often resulted in encroachments, real or alleged, by abutting property owners, and boundary disputes frequently were taken into court. Therefore, there was great need for the local survey coordination and reform of methods.

During 1935, 1936 and 1937 the engineering department devoted all available time to a complete control re-survey of the city. Subdivision and block corners, 2,600 in all, were investigated and established. Gas pipe markers were placed in all block corners and were tied in to sidewalks and other permanent points. These data were recorded in notebooks and on individual plats of each block for future reference and addition.

During 1935 and 1936 the $3 city charge for lot re-surveys was continued in order to keep the demand for this service at its former low level while the surveying crews were working their records into usable shape. However, as the control survey neared completion in 1937 it was found that the individual lot re-surveys could be made with a minimum of effort and the charge could be discontinued.

Since 1937, 1,200 lot corners have been established in re-surveys. As there is no surveyor in Fort Dodge soliciting this type of work the city is not competing with private members of the profession. Property owners have voiced universal approval and appreciation of the project, and to date no disputes over lines have reached the litigation stage. A special effort was made to acquaint the local lawyers with methods used and difficulties encountered. This procedure has inspired their confidence and helped prevent disputes.

Culverts for Mosquito Control

Contents in Brief *— Drainage structures in Memphis must be constructed to eliminate the possibility of mosquito breeding as well as provide for the usual service in removing stormwater. Evolution in design has resulted over the flat bottom type so widely used. Structural and hydraulic details of correct design are given.*

LOCATED IN THE CENTER of the malaria mosquito belt, Memphis exercises particular care in the installation of drainage structures. Not only must culverts and ditches be adequate for stormwater needs but they likewise require the incorporation of features which prevent the breeding of mosquitoes. What Memphis has learned about building culverts to serve these dual needs is summarized in the following extracts from a paper by City Engineer William B. Fowler presented at a recent meeting of the National Malaria Committee.

All drainage construction work is now conceived as malaria control work, and features important to control technique are being included throughout the existing drainage system. This has raised questions of new culvert design as well as improving the design of ditch bottoms and securing proper grades to maintain scouring velocities.

Concrete box culverts

Prior to 1911, it was general practice in Memphis to construct concrete box culverts with flat bottoms, such as indicated in Fig. 2 (top). This type of culvert, which is still standard design in many parts of the country, has no special provision for dry weather flow. The wide flat bottom permitted the accumulation of silt and debris to such an extent that the dry weather flow had to seek a channel through the sediment with resultant pockets and pools. Such a condition not only created mosquito breeding places but also seriously reduced the capacity of the culvert for carrying floodwaters.

About 1911, the city adopted a parabolic section for box culvert bottoms. This step in the evolution of the concrete culvert served partially to concentrate the dry weather flow in the central portion of the bottom (Fig. 2, center). On the smaller culverts the result was satisfactory. However, on the larger and wider sizes, there was still some of the same trouble that was characteristic of the flat bottom.

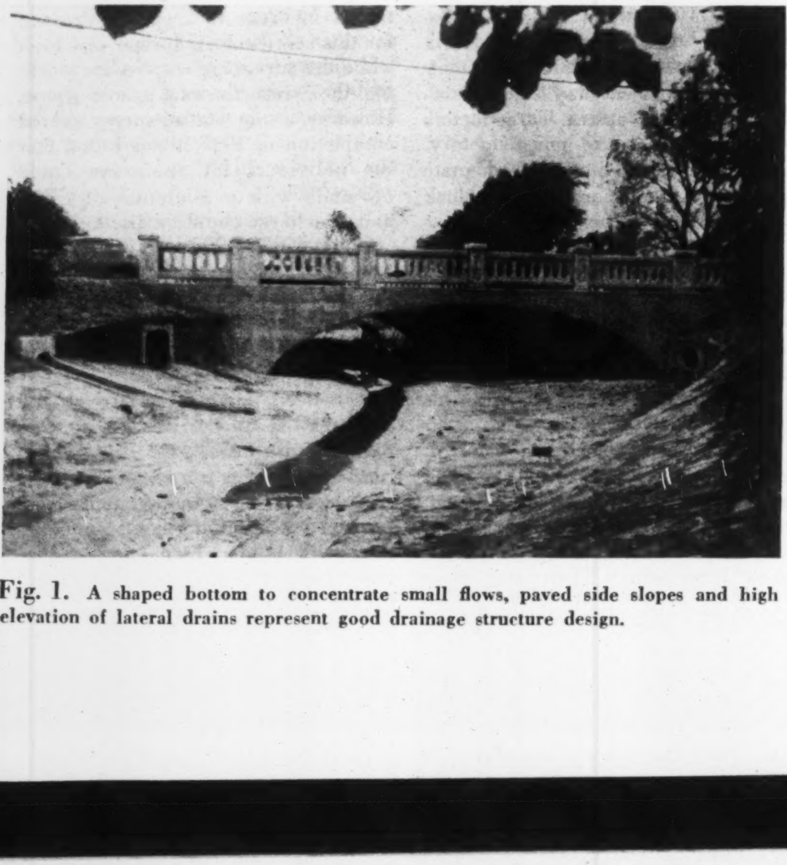
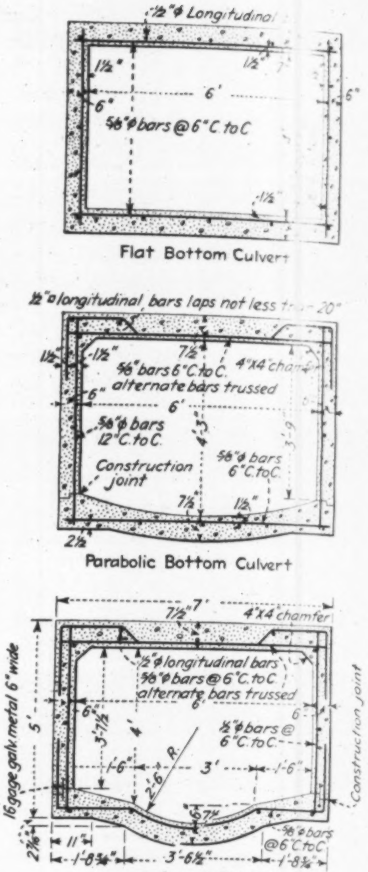


Fig. 1. **A shaped bottom to concentrate small flows, paved side slopes and high elevation of lateral drains represent good drainage structure design.**


½"φ Longitudinal
1½"
1½"
6'
6"
6"
⅝"φ bars @ 6" C. to C
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1½"
1½"
7½"
⅝" bars 6" C. to C.
alternate bars trussed
4"x4" chamfer
6"
6'
⅝"φ bars
12" C. to C.
4'-3"
3'-9"
⅝"φ bars
6" C. to C.
Construction joint
7½"
1½"
2½"
7'
7½"
4"x4" chamfer
½"φ longitudinal bars
⅝"φ bars @ 6" C. to C.
alternate bars trussed
6'
16 gage galv. metal 6" wide
5'
6"
3'-7½"
4'
R.
2'-6"
½"φ bars @
6" C. to C.
6
1'-6"
3'
1'-6"
7½"
Construction joint
⅝"φ bars
@ 6" C. to C.
2⅞"
11"
1'-8¾"
3'-6½"
1'-8¾"

Flat Bottom Culvert

Parabolic Bottom Culvert

Circular Invert Culvert

Fig. 2. **Evolution of box culvert design in Memphis. The latest design provides a shaped bottom to concentrate small flows.**

Structurally, the parabolic section is better than the flat bottom design because it places the reinforcing steel to a better advantage. The straight bars in the bottom are close to the inside face at midspan so as to provide reinforcement for positive bending moment, and they are near the outside face at the corner to provide reinforcement for negative bending moment. Steel at the top corner is carried around the corner on the outside face to make these corners fully rigid. During later years, the design was modified to make the bottom corners fully rigid by bending the bottom steel upward on the outside face of the sidewalls.

In January, 1938, the engineering

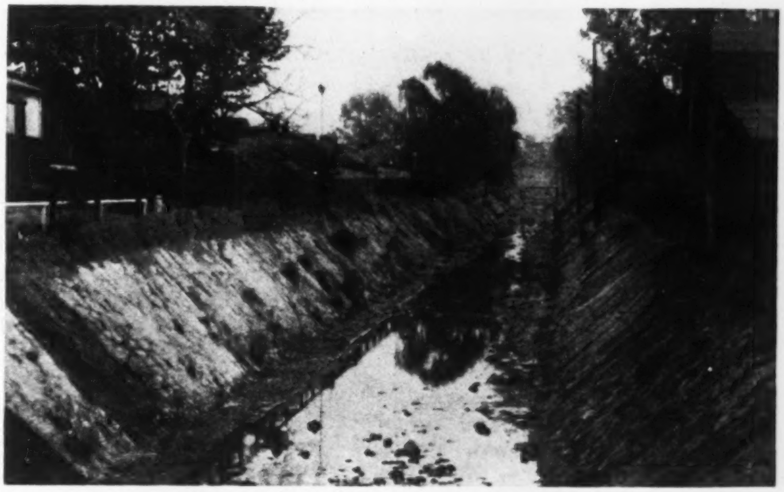


Fig. 4. Unlined, flat bottomed drains, such as this become veritable incubators for mosquito breeding.

department again revised the design for concrete box culverts. This produced the present circular invert culvert shown in Fig. 2.

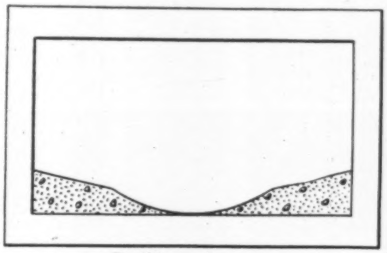
The point of variance is again the shape of the bottom. In this design specific provision has been made for the dry weather flow by providing a circular invert 3 ft. wide and 6 in. deep in the center of the culvert bottom. From the edge of this invert, the bottom slopes upward to the sidewalls at the rate of three inches rise per foot. This has been made standard in all sizes. Structurally, the bottom still has the characteristics of a slab, and the first step in design so treats it. The central portion or invert is then checked for arch action, and then the portion between the invert and the sidewall is investigated as a cantilever fixed at the corner with a uniform load plus the concentrated load of one-half the invert section at the junction with the invert section.

The purpose of this design is to provide a dry weather or low water channel to concentrate small flows so as to provide, as nearly as possible, a self-cleaning culvert with the bottom sloped to deflect all deposits towards the center channel. With this design it is possible to carry the same bottom section through open ditches and closed culverts.

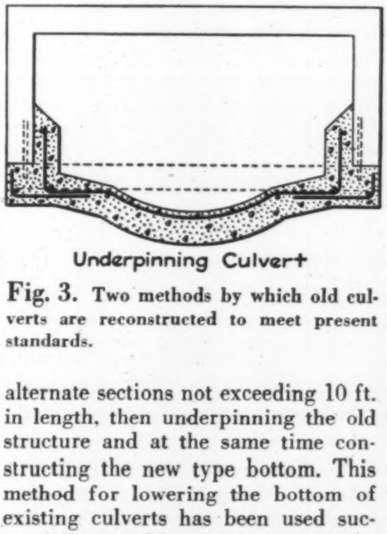
Revamping existing culverts

Obviously it is not economical to replace the miles of culverts previously constructed using the flat and parabolic bottom design. However, it is highly desirable to provide, wherever possible, a uniform ditch and culvert bottom section throughout the drainage system. Two methods have been successfully worked out to accomplish this purpose, and these are illustrated in Fig. 3.

The first method merely reduces the effective area of the culvert by building up the desired section inside the old culvert. This loss of area is not as serious as it appears at first glance, as actually the flat sections have an accumulation of silt and debris which reduces the area often as much as the added concrete which is required to build up the new section.



Built up Invert



Underpinning Culvert

Fig. 3. Two methods by which old culverts are reconstructed to meet present standards.

The second method is used where it is found desirable to increase the capacity of the existing culvert. In this instance the flow line is lowered by breaking out the old bottom in alternate sections not exceeding 10 ft. in length, then underpinning the old structure and at the same time constructing the new type bottom. This method for lowering the bottom of existing culverts has been used successfully in Memphis since 1935, when it was originated as a method to increase the capacity of existing culverts and also to lower the flow lines of individual culverts to conform to established grades worked out for the entire drainage system.

The underpinning method has proved entirely practical, and considerable savings have been made by thus salvaging the old culverts and eliminating costly excavation, shoring, and bracing. By this method, culvert capacities have been increased under existing buildings where it would have been almost impossible to construct new culverts of adequate size.

It is interesting to report that 99 miles of the 222 miles of drainage facilities in Memphis has been covered with pipe or culverts. An additional 66 miles has been lined with concrete, most of which distance consists of small ditches. Half of the remaining 57 miles is included in recent project applications for concrete lining construction.

Grades and flow velocity

In connection with ditch installations it has been found that those having a gradient of more than 1 per cent were able to maintain themselves in a clear condition, if provided with adequate outlets, and with little consideration being given to alignment or invert cross-section. Ditches with gradients less than 0.3 per cent have not proved satisfactory, all other conditions being ideal. Between these two grades, it was necessary to design the cross-section by varying the radius of the invert.

The narrow sub-channel in the center of the ditch therefore should be designed to produce a mean depth of flow sufficient to produce a minimum velocity of 2 ft. per second.

This velocity is regarded as being the minimum which will properly prevent the deposition of silt and the subsequent stoppage of water in the bottom of the ditch.

FROM FIELD AND OFFICE

Working problems and time-saving methods . . . Edited by Charles S. Hill

Vibrator Compacts Backfill

John Girand
Phoenix, Ariz.

Earthfill behind a concrete retaining wall on the Central Ave. underpass in Phoenix, Ariz., was successfully compacted with an internal type concrete vibrator. There was insufficient clearance between the wall and side of the cut to use the usual type of compaction roller. As the volume of backfill was too large for hand tamping economically, P. F. Glendenning, resident engineer, suggested using a concrete vibrator.

The moisture content of the backfill material was kept constant. Trucks dumped the material behind the wall, and two men handled one of the larger vibrators. The action of the loose dumped earth when vibrated was much like that of stiff concrete. A pile of dumped material would flatten out when vibrated, settling down into a compact mass. No further compaction was required.

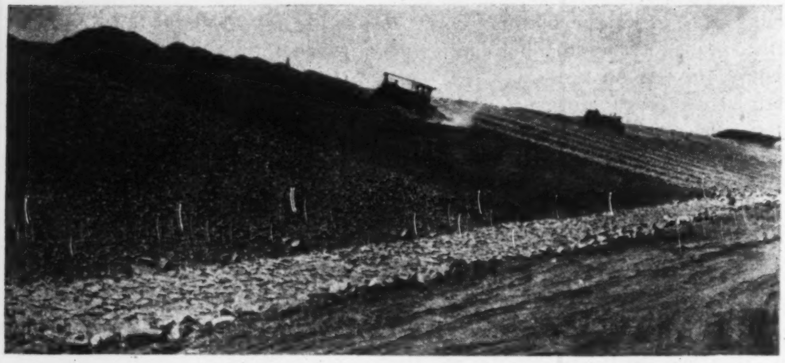
The Lee Moor Construction Co., El Paso, Tex., was contractor on the project for the Arizona state highway department.

• • •

Bulldozer Spreads Stone On Dam Slopes

Rock spalls had to be spread 6 to 8 in. thick on the upstream face of Hansen Dam in southern California to serve as a bedding layer for the hand-placed rock with which the surface was finished. An economical and effective means of spreading was to dump the spalls at the upper edge of the slope, at successive stages of the work, and to spread them by working a bulldozer down the slope pushing the rock ahead.

The toe of the slope is shown in the accompanying illustration with some of the hand-placed rock facing already in place. In the left foreground the layer of spalls has been spread; at the top of the slope are seen the stone piles left by the dump trucks, ready for spreading, and in the background a bulldozer is climbing back up the slope.



Successive stages of spall-spreading operations on the upstream face of Hansen Dam.

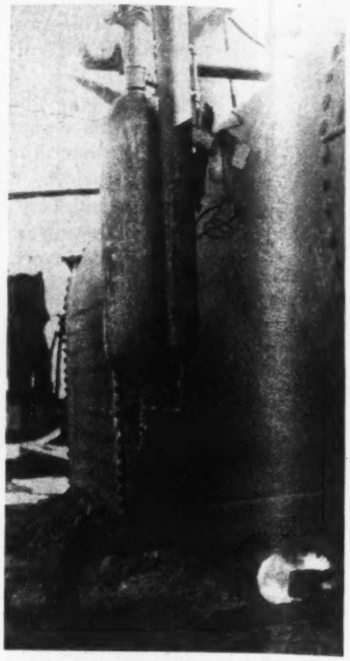
• • •

Steam Lubricator

M. T. Pate
Longview, Tex.

Steam-driven units on the job, such as water pumps, electric generators and air compressors, are much like automatic engines in that they frequently suffer most severe wear at the time of being started, the first few revolutions in an unlubricated state causing more abrasion than many hours' use when properly lubricated.

One contractor, recognizing this factor in equipment life, mounts a lubricator adjacent to the boiler, so that by the time the boiler has been heated sufficiently to generate the required steam pressure, the lubricator has been thoroughly warmed, and must feed only fluid, instead of cold and possibly congealed, lubricant into the line, there to be carried with the steam to every moving part contacted.



Set close to the boiler this lubricator supplies warm fluid oil as soon as steam is up.

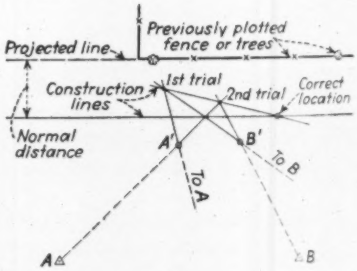
In especially severe weather a shield is set up around the outside of the lubricator, still further insuring absorption of heat from the boiler and resultant fluidity of the oil.

• • •

Plane Table Location

E. Neil W. Lane
National Park Service
Omaha, Neb.

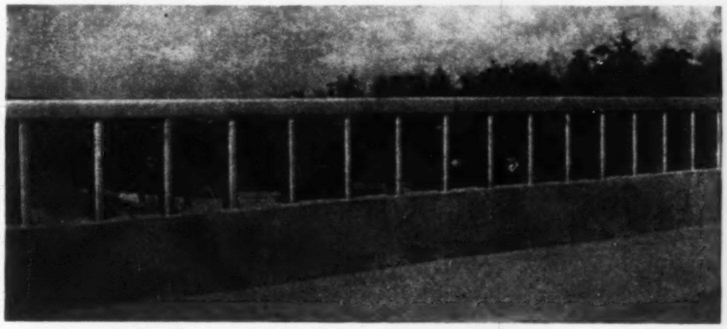
A plane table operator is sometimes confronted with the problem of orienting his sheet when only two control points are visible, though other topographic features may be seen.



Method of orienting plane table sheet from two control points.

Generally, convenient use can be made of a line between two of the topographic features that have previously been plotted on the working sheet by aligning oneself with the two points and measuring the distance normal to the plane table. This can be done by stadia or, if it is within the accuracy of the scale, by pacing. This distance can then be scaled and a line drawn on the sheet parallel to the two features used for line.

The true location is somewhere on this line and the actual point can be found by two trial intersections from the visible control points by a procedure similar to that described by Jones and Basten in their article "Three-Point Problem Simplified" that was published in *Engineering News-Record*, Oct. 12, 1939, p. 488.



A CURB HANDRAIL

On recent bridgework notice was taken of a barrier curb topped off by a metal handrail. Galvanized metal is used and 15-ft. lengths of rail and uprights are assembled by welding in the shop and shipped to the bridge where the bottoms of the uprights are set in the curb forms and concreted around as the curb is concreted. The rail is about 5x6 in. in cross-section and the uprights 2x4 in. The rail as shown cost about $5 a foot.

• • •

Culvert Layout System and Check

Charles L. Rodgers
Tennessee Valley Authority
Cleveland, Tenn.

When laying out culverts or small bridges, it is convenient to have a system of staking that will afford a positive check on the layout. Such a system is illustrated by Figs. 1 & 2, being the layout of a rectangular and a skew culvert, respectively. The heavy lines represent the inside face of barrel walls, the outside face of headwalls, and the face of wingwalls. The tacked reference hubs are set on extensions of these lines.

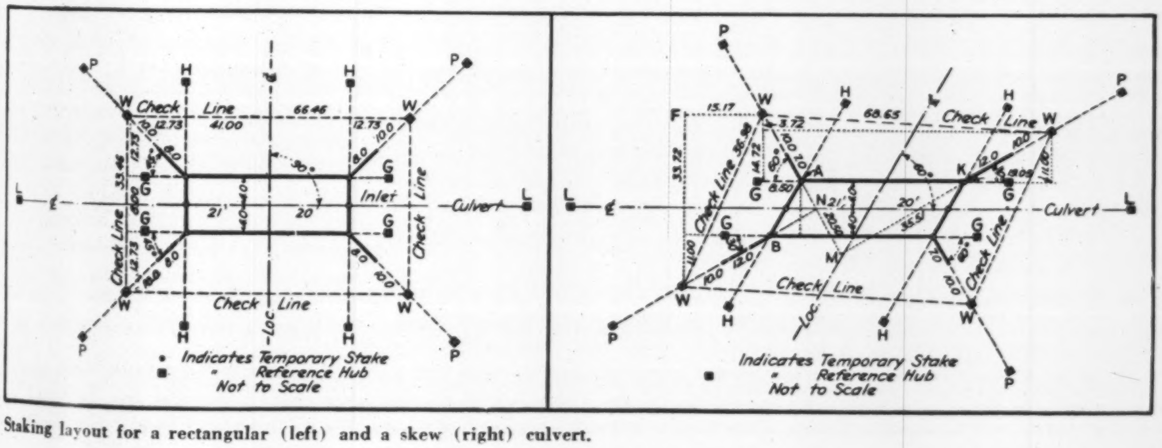
The system is the same for both types and can be adapted to almost any flared wingwall structure.

The procedure of staking is as follows: when the centerline of culvert is established and fixed by hubs *L-L*, temporary stakes are set at its intersection with the face of headwall line. From these two points the headwall line is turned off and reference hubs *H* are set; at the same time temporary stakes are set at the four corners of the barrel.

As these four corners are occupied, in turn, by the transit, in each case the reference hub *G* is set first, at 10 to 15 ft. from the end of barrel and is used for both line of barrel walls and grade of culvert floor, by extending the flow line grade to these points. The wingwall line is then turned off and the first reference hub *W* is set at some convenient distance from the end of the wing wall (10 ft. has been found satisfactory in most cases); it is important that this distance be the same for all four wingwalls, as this determines the final check of the layout. The second reference hub *P* on the wingwall line need not be measured accurately, as it is for line only.

This completes the layout of the structure. It will be noted that the wingwall reference hubs *W* form a parallelogram around the culvert, and the measured distance between them should agree with the computed sides of the parallelogram. As each step of the layout is dependent on the one preceding it, an error in any one of them will result in a discrepancy between the measured and computed lengths of two sides of the parallelogram.

In the skew culvert, Fig. 2, two methods are shown. If the structure follows conventional design, in which the wingwall line bisects the angle formed by the barrel and headwalls, the check line across the culvert may be obtained by calculating the two right triangles *ANB* and *WNW;* and similarly, for the lengthwise check line, by the two right triangles *AMK* and *WMW*. The second method is illustrated by the series of right triangles having their legs parallel and perpendicular to the centerline.



Staking layout for a rectangular (left) and a skew (right) culvert.

BOOK NOTES AND REVIEWS

The month's additions to the engineer's reading and reference list

For All Contractors

WAGE RATE LAWS ON PUBLIC WORKS—Published by the Federal Works Agency. For sale by the Superintendent of Documents, Washington, D. C. Price 25c.

Brought together in concise form in this pamphlet are the federal wage laws relating to public works, such as the Bacon-Davis act, pertinent sections of other acts, opinions of the Attorney General and the Comptroller General bearing on wages and extracts from pertinent court decisions; also included are state and territorial laws bearing on wage rates for public works, opinions and court decisions. The data given in the pamphlet were compiled by the Public Works Administration for checking contract documents on PWA projects.

A.S.T.M. Standards In a New Form

A.S.T.M. STANDARDS 1939—Part I, Metals, 1,308 pp. Part II, Nonmetallic Materials—Constructional, 1,217 pp. Part III, Nonmetallic Materials—General, 1,175 pp. Published by the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. Prices for non-members: any one part, $8; any two parts, $15; all three parts $22.

Departing from the publication arrangement of its widely known standard specifications, the American Society for Testing Materials this year has adopted the plan of grouping standards and tentative standards under the same covers, instead of publishing them in separate volumes as heretofore. To make the new form feasible, the society found it necessary to divide the entire group of standards into three sections, covering, respectively, metals, constructional non-metallic materials, and general non-metallic materials (fuels, rubber, textiles, insulating material and the like).

To every one who buys, sells, or tests the quality of material, this collection of standards is an indispensable reference document. It will be the more valuable in use because of the plan to publish during the coming year and the next supplementary volumes containing new and revised specifications, so that the set of volumes can be kept up to date without waiting for the next triennial issue.

Two-column arrangement of the text matter as compared with the former wide measure also makes the specifications more readable and convenient.

A Page from History

THE OHIO BRIDGE—By Harry R. Stevens. 213 pp. Privately published for the Covington & Cincinnati Bridge Co. by The Ruter Press, Cincinnati.

"From Steubenville to Cairo, the Cincinnati-Covington suspension bridge was the only crossing open on the Ohio River" in the great 1937 flood, and it rendered invaluable service in moving emergency food and medical supplies to flooded communities. This item from the 100-year record of the bridge helps to justify the proud name given to it by the author of an interesting historical document entitled "The Ohio Bridge." Despite some vagueness and crudity in technical detail, the book is an important contribution to the history of early bridge construction in the United States, particularly the era of Charles Ellet's and John A. Roebling's suspension bridges.

It is interesting to find that even back in the '40s the proponents of large bridges were opposed by those who "would consider any bridge an obstruction even if it were 200 ft. high." Roebling's apt reply, "Such objections are of course beyond the reach of argument and not deserving of any notice," did not prevent a delay of more than a decade. Thereafter came the great panic of 1857, of which it was said as of the current depression that "the prosperity from 1850 to 1856 was just an illusion, it seemed, and now the illusion had vanished."

The engineering reader will wish that the difficult problems of maintaining and later reinforcing the bridge were presented more fully. Rusting of the cable wires at the anchorages after 25 years of service necessitated repairs, and later the bridge was strengthened by the addition of a second set of cables. But after all the value of the book lies in its sketch of the development of the project from the earliest dreams soon after 1800 to its final realization at the close of the Civil War.

A Study of PWA

GRANTS-IN-AID UNDER THE PUBLIC WORKS ADMINISTRATION—By J. Kerwin Williams. 292 pp. Published by Columbia University Press, 2960 Broadway, New York City. Price $3.75.

Because of the continuing pressure on Congress to continue large contributions to local work relief operations, this study of the merits and defects of the vast program administered by the Public Works Administration is very timely. In presenting this analysis of the application of grants-in-aid, Mr. Williams discusses the new pattern of federal-state-local relations that came into being in 1933. He clearly sets forth the manner in which PWA was administered and organized, and much is said about policies, particularly in regard to labor and contractors.

This study is not concerned with the problem of whether public works can be used as a "pump primer." The author deals only with administrative procedures and his discussion provides practical information for the evaluation of future developments in the field of federal public works assistance.

MISCELLANEOUS NOTES ON BOOKLETS AND REPRINTS

USE AND ABUSE OF WOOD IN HOUSE CONSTRUCTION is the subject of Miscellaneous Publication 358, U. S. Department of Agriculture. Price 10c from the Superintendent of Documents, Washington, D. C.

A STUDY OF THE PRESENT STATUS and trends in engineering education in the United States, made for the Engineers' Council for Professional Development by Prof. Dugald C. Jackson, has been published by the Council in pamphlet form and may be obtained from C. E. Davies at 33 W. 39th St., New York City, for $1.

A UNIQUE DOCUMENT has been privately published by Edward E. Wall, Director of Public Utilities, St.

(*Continued on p. 78*)

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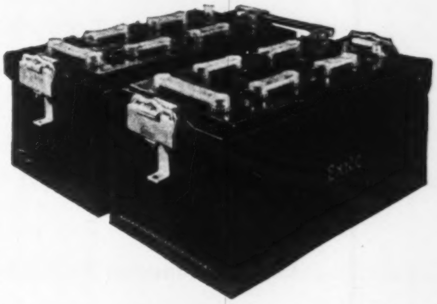
Their Diesel engines are cranked by Exide Batteries, and the average battery life at present exceeds 150,000 miles. Pacific Intermountain Express, Inc., says that Exides play an important part in the operation, and that they fulfill every requirement with complete satisfaction.



Other operators of Diesel-powered equipment, whether it is a fleet of trucks, road building or excavating equipment, tractors or stationary engines large or small, will find the same dependable, long-life service in Exides used for Diesel engine cranking. For "cycling" service we offer these batteries in wood and fiberglas separator construction. Write today for further information.

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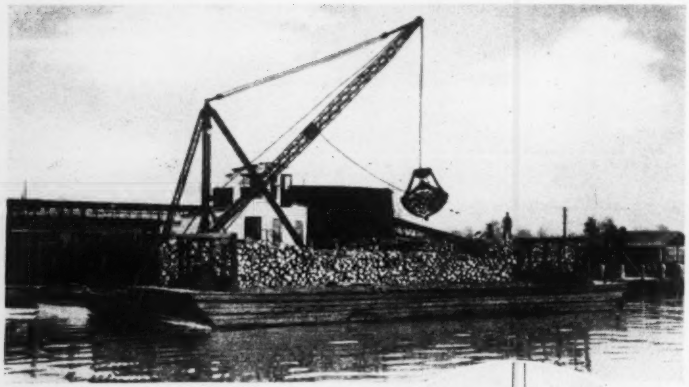

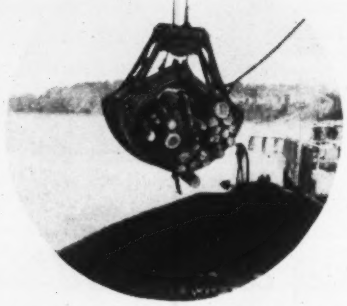

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DEALERS WITH STOCK IN ALL PRINCIPAL CITIES

MISCELLANEOUS NOTES ON BOOKLETS AND REPRINTS

(Continued from p. 76)

Louis, in the form of a pamphlet entitled "Literary Productions of Two Civil Engineers." The pamphlet contains an exchange of correspondence on a variety of subjects, all written in verse, between Mr. Wall and Jacob D. Von Maur, engineer of distribution, Consumers Gas Co., Toronto, that originated when Mr. Von Maur wrote to Mr. Wall in verse congratulating him on his election to honorary membership in the American Society of Civil Engineers.

WATER REQUIREMENTS OF RICE IRRIGATION is the subject of a paper published in mimeographed form by the Iowa Institute of Hydraulic Research, State University of Iowa, Iowa City. The paper covers studies made both in this country and in Asia and develops an empirical formula for estimating the net duty of water for rice irrigation.

A TYPE OF PRESSURE CELL based on the vibrating wire method for measuring strain is described in a reprint from the Canadian Journal of Research entitled "Description of a Pressure Cell for the Measurement of Earth Pressure," available from the National Research Conference of Canada, Ottawa, Ont.

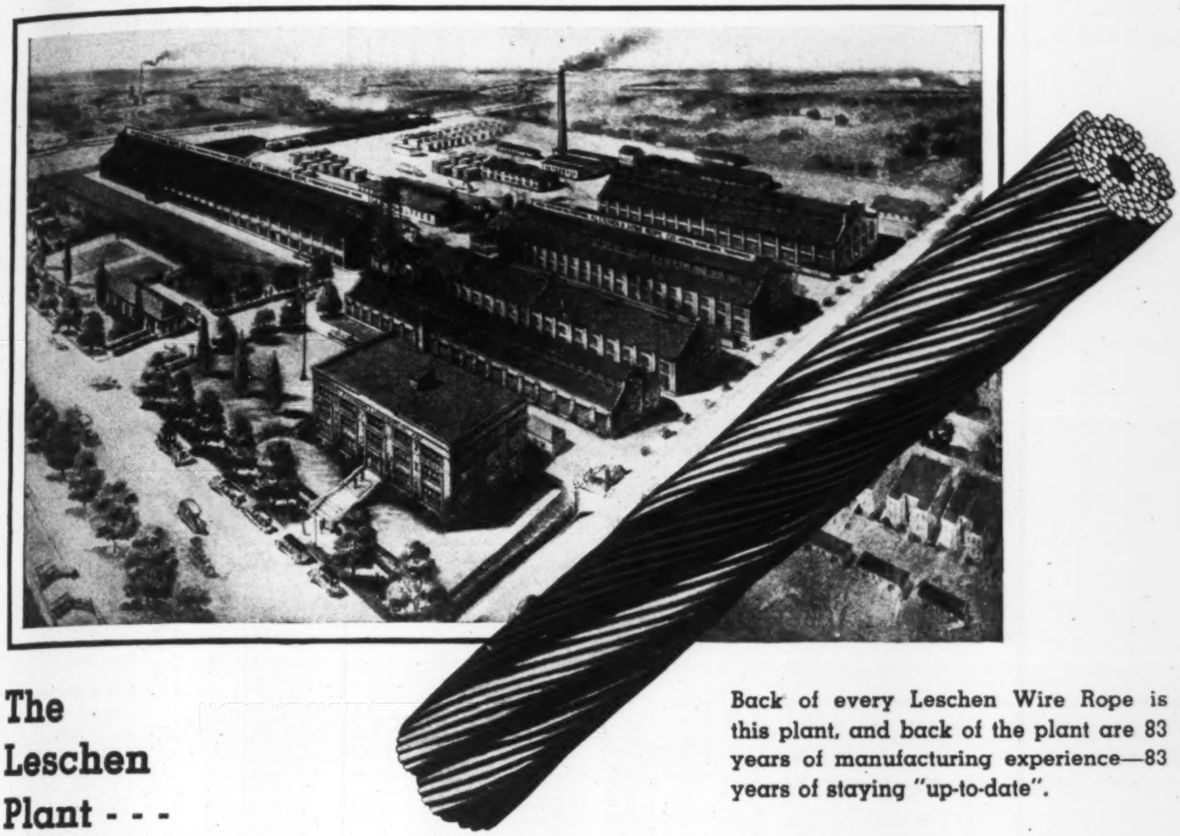
THE STRENGTH AND DEFORMATION of some reinforced concrete slabs subjected to concentrating loading is the subject of Paper No. VIII of "Studies in Reinforced Concrete" by the Department of Scientific and Industrial Research of Great Britain. Copies are obtainable from the British Library of Information, 50 Rockefeller Plaza, New York. Price, 40¢.

NEW ENGINEERING BOOKS

PRODUCTIVITY, WAGES AND NATIONAL INCOME—By Spurgeon Bell. 344 pp. Published by The Brookings Institution, 722 Jackson Place, Washington, D. C. Price $3.

AN AIR-CONDITIONING PRIMER—By William Hull Stangle. 236 pp. Published by McGraw-Hill Book Co., Inc., New York and London. Price $2.50.

(Continued on p. 82)



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CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work

HIGHWAYS, NEVADA

OWNER: Nevada Department of Highways, Carson City, Nev.; Robert A. Alen, state highway engineer.

PROJECT: Constructing 12.61 miles of highway from California-Nevada state line to Jean, Route 6, Section A, Clark County, Nev.

CONDITIONS: Contractor to furnish all materials and complete work by Sept. 23, 1940. Railway transportation facilities available. Wage rates specified are: skilled, $1.00 per hr.; semi-skilled, 70c. per hr.; and common labor, 62½c. per hr.

BIDS: Eight bids were opened March 15, 1940, ranging from the contract low of $145,511 to $163,841.

LOW BIDDERS:

1. Carl E. Nelson, Logan, Utah (contract)	$145,511
2. Silver State Constr. Co., Fallon, Nev.	157,117
3. J. A. Casson Co., Hayward, Calif.	159,481

Item	Quan.	Unit Prices		
		(1)	(2)	(3)
1. Selected detour surfacing	2,500 ton	$0.14	$0.28	$0.10
2. Haul on sel. detour surf	6,500 ton mi.	.06	.05	.08
3. Liq. asphalt, type MC-2, roadmix	771 ton	12.30	13.00	13.00
4. Roadmix detours	12.92 mi.	175.00	350.00	300.00
5. Spec. detours (set by engr.)	Force Acc.	1,000.00	1,000.00	1,000.00
6. Motor grader with scarifier	150 hr.	3.75	5.00	4.00
7. 1½-ton truck	150 hr.	2.00	1.50	2.25
8. Signs	L. S.	250.00	100.00	500.00
9. Remove culvert pipe	1,278 l. f.	.40	.40	.50
10. Remove headwalls	64 ea.	3.00	5.00	5.00
11. Remove and stockpile roadmix surf.	148,000 s. y.	.015	.03	.03
12. Roadway excavation	71,899 c. y.	.14	.14	.11
13. Drainage excavation	816 c. y.	.20	.14	.11
14. V-type ditches	231 sta.	2.00	5.00	1.25
15. Borrow	6,128 c. y.	.14	.18	.11
16. Overhaul	186,687 y. sta.	.005	.01	.008
17. Overhaul	2,860 y. mi.	.10	.10	.12
18. Structure excavation	2,664 c. y.	.75	.90	.75
19. Backfill	2,366 c. y.	.35	.40	.35
20. Subgrade, type B	12.61 mi.	100.00	200.00	150.00
21. Salvaged aggr. shoulders	118,384 s. y.	.02	.04	.03
22. Roadside cleanup (set by engr.)	Force Acc.	500.00	500.00	500.00
23. Water	5,335 M gal.	1.50	.75	1.10
24. Type 1, gravel base	63,905 ton	.19	.22	.22
25. Type 2, gravel base, 1½-in. size	48,141 ton	.29	.29	.35
26. Liq. asph., type MC-1, prime	293 ton	13.00	13.00	13.50
27. Liq. asph., type SC-1A, prime	117 ton	11.30	12.00	11.50
28. Liq. asph., type SC-2, seal	120 ton	10.20	11.50	11.00
29. Screenings	1,079 ton	1.50	1.75	2.00
30. Liq. asph., type MC-4 or 5, seal	151 ton	12.80	13.00	13.00
31. Class A concrete	871 c. y.	18.00	20.00	22.00
32. Class B concrete	26 c. y.	18.00	20.00	28.00
33. Reinforcing steel	94,350 lb.	.04	.05	.05
34. 24-in. corr. met. pipe, dipped	266 l. f.	2.40	3.00	2.75
35. 30-in. corr. met. pipe, dipped	90 l. f.	3.00	4.00	3.50
36. 36-in. corr. met. pipe, dipped	58 l. f.	5.00	6.00	6.00
37. 30 by 17-in. c. m. arch pipe, dipped	472 l. f.	2.70	3.00	3.50
38. Relay culvert pipe	614 l. f.	.40	.50	.50
39. Move pipe culv. headwalls	42 ea.	8.00	5.00	15.00
40. Culvert markers	32 ea.	2.00	3.00	2.50
41. Guide posts	8 ea.	2.00	3.00	2.50
42. Monuments	59 ea.	2.00	3.00	3.00
43. Liq. asph. SC-4 or SC-5, plant-mix	1,076 ton	10.50	13.00	10.50
44. Cl. B-2 plantmix bitum. surf	23,261 ton	1.26	1.08	1.25
45. Cl. B-2 plantmix bit. surf. dikes	217 ton	2.00	2.00	2.25
46. Remove, reset culvert markers	106 ea.	.40	1.00	1.50

PIERS AND ABUTMENTS KETTLE FALLS BRIDGE

OWNER: Bureau of Reclamation, Columbia River Reservoir, Columbia Basin Project, Coulee Dam, Wash.

PROJECT: Construction of piers and abutments for Kettle Falls bridge over Columbia River for relocation of Great Northern Railroad. Work located near Kettle Falls, Wash.

CONDITIONS: Government to furnish cement, reinforcing bars, pier-nose angles anchor bolts and pipe sleeves for anchor bolts, metalwork for erection anchors; contractor to furnish sand, rock, gravel, all backfill materials and all form material. Access roads to be provided by contractor. Great Northern Railroad passes through Kettle Falls. Project to be completed in 150 calendar days after commencement. Wage rates specified: skilled labor, $1.65 per hr.; semi-skilled, $1.25; and common labor, 70c. per hr.

BIDS: Fourteen bids were opened March 27, 1940, ranging from the low of $109,990 to $198,610.

LOW BIDDERS:

1. A. A. Prendergast & Assoc., and Industrial Contr'g. Co., Minneapolis, Minn.	$109,990
2. Morrison-Knudsen Co., Boise, Idaho	118.600
3. Angeles Gravel & Supply Co., Port Angeles, Wash.	119,200

Item	Quan.	Unit Prices		
		(1)	(2)	(3)
1. Excav. common, abutments and piers	7,900 c. y.	$0.55	$0.25	$0.40
2. Rock excav., abutments and piers	6,000 c. y.	3.00	4.25	3.00
3. Concrete in abutments	1,950 c. y.	10.50	10.50	10.00
4. Conc. in piers below top of bases	1,980 c. y.	6.50	7.50	7.00
5. Conc. in piers above top of bases	4,640 c. y.	8.65	8.50	10.00
6. Place reinforcing bars	580,000 lb.	.0125	.017	.015
7. Backfill	10,400 c. y.	.50	.20	.30
8. Compacting backfill	7,400 c. y.	.20	.50	.80
9. Place misc. metalwork	18,000 lb.	.013	.04	.03

SEAWALL, BROOKLYN, N. Y.

OWNER: Department of Parks, Arsenal Bldg., Fifth Avenue, New York, N. Y.; J. J. D'Arcy, engineer.

PROJECT: Construction of seawall and walk, Fort Hamilton to Bay Parkway, Brooklyn, N. Y.

CONDITIONS: Contractor to furnish all materials. Rail, highway and water transportation facilities available. Wages specified are: skilled, $1.15 to $2.12½ per hr.; semi-skilled, 52½c. to $1.50; and common labor, 50 to 87½c. per hr.

BIDS: Twenty-four bids were opened January 16, 1940, ranging from the contract low of $663,000 to $913,869.

LOW BIDDERS:

1. Garafano Constr. Co., Mt. Vernon, N. Y.	$663.000
2. Elmhurst Contracting Co., Inc., Long Island City, N. Y.	667,514
3. Tully & DiNapoli, Long Island City, N. Y.	689.890

Item	Quan.	Unit Prices		
		(1)	(2)	(3)
1. Unclassified excavation	35,500 c. y.	$0.25	$0.55	$0.55
2. Trim shoulders	L. S.	3,000.00	1,500.00	1,000.00
3. 15-in. rein. conc. pipe	400 l. f.	3.00	1.25	1.40
4. 18-in. rein. conc. pipe	12 l. f.	5.00	2.00	2.00
5. 24-in. rein. conc. pipe	800 l. f.	6.00	4.25	2.75
6. 36-in. rein. conc. pipe	12 l. f.	20.00	5.00	5.50
7. Portland cement	35,000 bbl.	2.05	1.95	2.35
8. Natural cement	7,400 bbl.	2.85	3.00	3.20
9. Cl. 1 conc., 1:2:4 mix	23,600 c. y.	9.00	8.20	6.25
10. Dimension masonry	865 c. y.	60.00	63.00	76.65
11. Reinf. bars, structures	500 lb.	.20	.10	.05
12. Misc. iron and steel	23,000 lb.	.06	.06	.09
13. Metal railing	7,800 l. f.	4.00	4.50	3.70
14. Bitum. mat'l. A, penetr. method	36,000 gal.	.11	.09	.10
15. Bitum. mat'l. A, emulsion	9,000 gal.	.10	.10	.10
16. Stone filling	5,850 ton	1.00	3.00	3.30
17. Screened gravel, L.M	2,920 c. y.	2.50	2.75	3.00
18. Concrete edging	8,300 l. f.	.50	.50	.55
19. Timber and lumber	120 Mbm.	30.00	70.00	.20
20. Relaying old pipe	300 l. f.	3.00	1.00	.80
21. Move riprap foundation	L. S.	50,453.00	26,000.00	45,000.00
22. Riprap	1,800 ton	2.00	3.00	4.35
23. Stone masonry	1,200 c. y.	40.00	45.00	50.00
24. Stone masonry, salvaged	2,800 c. y.	25.00	26.00	34.50
25. Timber curbing	1,500 l. f.	.20	.20	.25
26. Protect traffic and utilities	L. S.	1,500.00	1,500.00	700.00
27. Temporary sheeting and bracing	18,000 s. f.	.05	.06	.30
28. Permanent sheeting and bracing	1 Mbm.	150.00	80.00	115.00
29. Riprap foundation	1,000 ton	2.00	2.75	3.35
30. Trim riprap foundation	7,780 l. f.	.65	2.50	1.55
31. Tarpaulins	144,000 s. f.	.04	.05	.05
32. Timber guide railing	760 l. f.	1.00	1.00	.90
33. Bitum. macadam paving, sidewalk	18,000 s. y.	1.77	1.30	1.70
34. Stone gutters	2,860 s. y.	1.75	2.00	2.35
35. Remove existing piles	L. S.	1,500.00	2,500.00	300.00
36. 24-in. cast iron pipe	100 l. f.	15.00	20.00	15.00